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ABSTRACT

This is the third of a three-volume set containing the papers and proceedings of the International Organization for Science and Technology Education (IOSTE). It includes a brief account of the symposium's design and structure, followed by: (1) a general introduction to the theme of the symposium; (2) an introduction to each of the thematic areas; (3) brief reports of the poster sessions and workshops; (4) findings of the three working groups; (5) an evaluative summary of the symposium; and (6) final recommendations. (ML)

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Science and Technology Education and the Quality of Life

Volume 3

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Science and Technology Education and the Quality of Life

Volume 3

Proceedings of the 4th International IOSTE Symposium on World Trends in Science and Technology Education

Kiel, 4 – 12 August 1987

IPN

Institute for Science Education
at Kiel University

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FOREWORD

Georg Za'rour
International Organization for Science and Technology Education

The papers that were received on time and approved for presentation at the Fourth International Symposium on World Trends in Science and Technology Education in August 1987 appeared in a two-volume publication distributed to all participants. This volume of **Symposium Proceedings** is a record of the plenary presentations and the reports of the various working groups in which all participants were involved. Of course, not all questions asked or points of view expressed will finally appear in print. The reports of the working groups are more of a distillation or a summary of the major issues and the positions adopted by the groups.

The Symposium brought together participants with a variety of cultures, interests, disciplines, and academic backgrounds. Formal professional presentations and discussions were interspersed with informal exchange of ideas about educational systems, teaching approaches, innovations, experiments, practices as well as touristic attractions and the climate. The benefits from these encounters vary from individual to another but, along with other interactions, form an important contribution of such a gathering. **Symposium Proceedings** can never reflect the friendships that are made, the professional fraternization that is experienced, and the informal interchange of information and ideas. According to its constitution, IOSTE "identifies science and technology education with the real and changing needs of humankind as a whole and with specific needs of its component communities and nations". One byproduct of the activities of IOSTE represented mainly by the Symposia is a greater understanding among people from all continents.

Our organization is maturing and our modes of operation are becoming increasingly institutionalized being guided by a constitution which was amended during the Fourth Symposium to allow for wider participation at the level of the chairperson. A number of regional representatives were also elected by secret ballot-a practice which should be generalized. In addition to an active STS interest group, new interest groups were established or were being planned with emphasis on the environment, technology, and curriculum development at the intermediate cycle.
Procedures that have been started to establish non-governmental relationships with UNESCO are being followed by the new Executive and plans for the Fifth Symposium in the Philippines were announced.

The professional status and contributions of the International Organization for Science and Technology Education is a reflection of its membership and their commitment. The Organization depends upon you, its members, to grow professionally and to realize its objectives. The new Chairperson and Executive are committed to its professional growth and I am confident that they have the support of all.

Finally, I take this opportunity to thank all IOSTE members for their confidence, cooperation, and support during my term of office as Chairperson between 1984 and 1987 and to transmit my greetings, best wishes, and regards to you all.

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1 WORDS OF WELCOME

1.1 Wolfgang Clausen

Under-Secretary of State,
Schleswig-Holstein Ministry of Education, Kiel

Ladies and Gentlemen:

The topic "Science and Technology Education and the Quality of Life" approaches one of today's basic questions. I am proud that such a highly qualified international symposium is taking place here in Kiel.

Having such a symposium here in Kiel confirms the special reputation the IPN - the Institute for Science Education at the University of Kiel - enjoys. The Schleswig-Holstein institute is financed by the Federal Government in Bonn and by all the States. The work at the IPN is recognized by both the theorists and the practicians. Various reports by nationally and internationally renowned specialists and by schools have confirmed the effectiveness of its work.

The chances young people have for the future, especially with regard to education and professional prospects, depend to a large degree on a productive society, an intact family, a healthy environment and social security. Science and technology play directly or indirectly an important role in almost all of these areas.

Technical advances determine more and more the productivity and competitiveness of the highly industrialized countries. There is NO alternative to technical advancement. Whoever prevents it endangers prosperity and employment. The opening up of new areas of production and the manufacture of goods at a highly technical and skilled level are essential for the Federal Republic of Germany. In no other large industrial country are so many jobs dependent on international competition for the well-being of the economy. The export of technological quality products and of technical know-how is a pillar of our economy. This is reflected in vocational requirements. Modern control, information, communications and assembly techniques are becoming more and more important. Schools are thus challenged to teach basic and specialized knowledge about science and technology.

In addition to this, the conservation of our environment is one of the most important tasks for the future. The investigation of ecological relationships, the observation of the environment by means of technical measurements and compensatory measures for unavoidable intrusion on nature demand increased scientific efforts and new technical developments. Thanks to scientific advances in the health sector, the possibilities for prevention, cure and rehabilitation have improved considerably. As a result, average life expectancy has risen.

Both goals, technical advance and preservation of our natural, fundamental life situation must enter into our thinking and our actions on an equal basis. A radical "either/or" is not right, but rather a reasonable "not only ... but also", whereby the decision must be made anew for each individual case.

The state government, therefore, believes that not only knowledge about science and technology is important, but that the connection between social and cultural viewpoints and environmental and economic viewpoints should be presented. This is important when trying to avoid difficulties in communication, fears, a feeling of helplessness and possible isolation. Knowledge of science and technology, their prospects and possible consequences and possible abuse reduces the danger of dependence, foreign rule and manipulation. Early protection of young people from these dangers is not only a question of an easier style of life or future perspectives in jobs. The question in the background is the citizens'assumption of responsibility as the prerequisite for securing a democratic state and society.

Widespread hostility towards technology is often mentioned. Here the danger in such hostility lies in the fact that technology is no longer viewed objectively. Our task is to realize that technology, technical and technological advances are supposed to help mankind. A renunciation of new technologies or of further development for fear of possible misuse could lead to a situation where the means of fulfulling the fundamental needs of a rapidly expanding world population are qualitatively and quantitatively insufficient.

Mankind's problems in the future cannot be solved without use of modern and developing technologies. The necessary acceptance of technology by the population can only be reached when those in science, industry, politics and education responsible for decision-making do the work necessary to convince others of the necessity in each individual case as early as possible.

In our opinion, that is in the opinion of the ruling state government, there is no general trend towards rejecting science and technology, either among the population in general or among young people. The majority of young people show an interest in technology. Scientific investigations confirm there is no general hostility towards technology as such on the part of the younger generation.

On the contrary, our assessment is that there are signs of an increasing interest in technical development and of the realization that technology is necessary for mankind's development:

- The number of students in technology and science is increasing, both in absolute and relative numbers.

- The number of pupils taking physics and chemistry at the upper secondary level is also increasing.

- There has been a sharp increase in the demand for computer courses in school and youth programs here in Schleswig-Holstein in recent years.

It may be of interest to you to learn what Schleswig-Holstein offers its schools in the line of science and technology. Science and technology has an important place in the syllabi. It begins with social studies in primary schools and goes on to arts crafts and technical education and to science education in the various secondary schools.

Arts and crafts and technical education have the following goals:

- to make the basic principles of technology clearer and more comprehensible and to qualify pupils to master life situations that are determined by technology.

- to teach basic technical skills as a prerequisite for mastering technical tasks.

- to realize the essential value of technology and to further develop it and to view technology as a possible source of danger.

- to comprehend technology as a component part of culture and technical education as a component part of education in general in a society formed by technology.

On restructuring the upper secondary level an increased emphasis was placed on science. This was done for two reasons: *first* to ensure an allround education and *second* to counter the tendency to drop difficult courses in math, physics and chemistry.
Every upper secondary level pupil must, take at least one science until the end. At the Gymnasium the treatment of technical questions is an integral part of physics. In the lower grades of the Gymnasium there is no place in the class schedules for technology as an individual subject.
Basic information technology may be seen as a supplement to basic science and technology education. Schleswig-Holstein is well advanced in its program to supply schools with computers.

In recent years Schleswig-Holstein has placed increased emphasis on environmental education. Between 1984 and 1986 all syllabi were re-worked with the assistance of representatives from schools, school administration, colleges, parent groups, churches, industry, teacher and professional associations. Environmental education became a more important part of biology, geography, physics and chemistry.

In primary schools more attention was given to plants and animals found in the locality. In the fourth grade the water cycle was added. The following topics were integrated into the new biology syllabi for grades 5 to 9:

- pest control measures using their natural enemies for biological plant protection.

- creation of biotopes for certain plants and animals.

- forests as areas of economic, recreational and protective importance.

At the upper secondary level general measures for maintaining the fundamental life situation are mentioned in connection with environmental protection. Area planning is covered at this level in addition to landscape care and protection measures.

I have attempted to give you here an outline of the subject as the Schleswig-Holstein government sees it. I would like to wish your symposium every success.

1 WORDS OF WELCOME

1.2 Klaus Hasemann

Federal Ministry of Education and Science, Bonn

Distinguished Guests, Ladies and Gentlemen, dear Colleagues:

It goes without saying that it is a great privilege for a country to have the most up-to-date developments in a particular sector of science delivered on its doorstep by the top personalities from all over the world. The Federal Republic of Germany can enjoy this privilege thanks to the decision of the International Organization for Science and Technology Education to hold its fourth international symposium in Kiel.

The Federal Minister for Education and Science, Jürgen MÖLLEMANN, has asked me to welcome you in his name. His special thanks are directed to the Institute for Science Education, the IPN, at the University of Kiel and the Kiel Teacher Training College, who have prepared and organized this symposium, as well as to IOSTE.

Minister MÖLLEMANN would like to address the following greeting to the participants:

"I believe the appointment IOSTE made to the IPN was in honorable, international recognition of the work being done for the development of science and technology education at the IPN, an institute not only important for the Federal Republic of Germany. The theme of this symposium - World Trends in Science and Technology Education - is a most important one for the Federal Republic of Germany.

As a country poor in natural resources our competitiveness, our growth and labour situation, our standard of living and social security depend to a large extent on the quality of science and technology education for wide sectors of the population. We must try to enable people to do their utmost in this area.

In the end, our ability to master essential processes in nature and technology and our ability to develop innovative procedures and products determines the quality of our contribution to science and technology development, especially in the so-called Third World for whom we feel responsible.

The further development of science and technology education in school, in vocational, in higher and in continuing education is, therefore, one of the main areas of concentration in educational policy in the Federal Republic of Germany and in the individual states of the Federal Republic.

It is only natural that the question the effects of science and technology and their mastery have are also included here as science and technology education must not simply mean communicating knowledge on science and technology.

The confrontation between the possibilities and the risks involved in using modern procedures and products is also an important factor. The private and professional life of every individual, the cultural and social development of society and the ability to maintain our life basis are considerably influenced by this confrontation. It is, therefore, the task of general, vocational, science and adult education to transmit the ability to view these questions objectively and importance oriented, and to promote an interest in active participation.

Each and every individual should be able to recognize and evaluate the contribution science and technology are able to make to safeguard the existence of current and future generations. The main questions are: How can technology be controlled? What are its positive or negative consequences for jobs and the environment? How can it be used meaningfully in various areas?

The teaching and learning of science and technology must make it possible to come closer to answering these questions. It is becoming more and more important for the working population to be in a position to understand, evaluate and shape the effects which the use of highly developed modern technolgy has on the conditions and organization of work, and on job opportunities. Security, safety and personal integrity should not be harmed. Of course, science and technology education must also do its part here.

Finally, arousing and forming a feeling of responsibility for our future is also important. Science and technology must not be used either at the expense of further generations - for example through undisciplined use of natural resources or irresponsible environmental damage - or to press the advantages the developed part of the world have against the so-called developing countries."

Minister MÖLLEMANN closes his remarks with the following words:

"I am glad that these and similar questions will play an important role in the talks and discussions during this international symposium. I hope that we will all be able to gain something through this international exchange of ideas for the further development of science and technology education for each of our countries, and thus for the protection of a life worthy for human beings on earth."

Considering the political goals presented by Minister MÖLLEMANN, I would like to add the following from the viewpoint of those responsible for certain aspects of educational planning at the Federal Ministry of Education and Science:

The younger generation's need for well-founded knowledge and skills in all areas of science and technology leads directly to the question of how the goal of communicating this knowledge and these skills to everyone can be reached, what can be taught, and how . It is not sufficient to demand and supply an increased amount of science and technology instruction. Increasing the number of physics laws or chemistry formulae in what is taught does not mean improving the quality of science education. This can only be achieved by increasing the motivation to spend time thinking about science and technology questions. It is a matter of motivating each individual to go beyond the requirements, beyond the required minimum. Or in terms of motivation psychology: The situational stimulus conditions must kindle an identification with the teaching goals that lead to the conviction that the expected results are useful and lead to a continuing interest as well as to a willingness to make an effort.

This, however, presupposes a principle turning away from what often happens in science teaching: teaching and learning must not be bound too closely to the subjects of the discipline, but rather must refer to the real life state of affairs in the world in order to untangle its complexities with scientific methods. As recent investigations by the host institute, the IPN, show most clearly, subject-oriented details learned in school are quickly forgotten; a fact which often leads to institutes of higher learning having to "begin at the beginning" again.

An important educational goal is not only the specialized knowledge of a few, but also the general knowledge required for everyone's everyday life when it comes to science and technology relationships and conditional factors of our world today. The attainment this goal requires considerable effort but it is worth it. Teachers and teacher trainers play a decisive role in reaching this goal. A high degree of flexibility and a willingness to innovate are demanded of them. People in responsible positions are called upon to do everything to help them.

With this in mind, Minister MÖLLEMANN and I would like to wish this symposium every success.

Thank you.

1 WORDS OF WELCOME

1.3 Faqir Vohra

United Nations Educational, Scientific and
Cultural Organization (UNESCO), Paris

Distinguished Participants, Ladies and Gentlemen:

It is my great pleasure and honour to extent to you, on behalf of UNESCO, a cordial welcome to the 4th International Symposium on World Trends in Science and Technology Education, with special reference to the Quality of Life. To you, Dr. CLAUSEN and Prof. Dr. HASEMANN, we are most grateful for having taken time out of your busy schedule to be with us to share your thoughts on this important subject.

We live in an age where science and technology are not only an integral part of our contemporary culture but are also the driving forces for our socio-economic development. As such, they have a decisive role in everyday human endeavours in urban and rural areas alike. Thus the rational use and application of science and technology can improve living standards and conditions. To do this, it is essential to have a public with a basic knowledge and an understanding of science and technology. Hence the need to incorporate both science and technology in the learning-teaching programmes of all people from as early an age as possible, and continued as an indispensable element of life-long education.

The aim of UNESCO's programme for "Teaching Science and Technology" is, therefore, to make young people more receptive to science and technology through improvement in content, methods and materials related to their education. Activities generally focus on three major areas: the promotion of innovation and experimentation, international and regional exchanges of information and experience, and the strengthening of national infrastructures and training capacities for science and technology education. The promotion of access by women and girls to science and technology education is also one of the basic concerns for the purpose.

In achieving this objective, UNESCO considers the establishment of relaltions of collaboration with non-governmental organizations as of great importance. Thus, in 1986, UNESCO was co-operating with 543 such organizations. Within the framework of this relationship, the NGOs are associated with both the preparation and the implementation of UNESCO's programmes. They are regularly consulted on the preparation of programmes by means of questionnaires. I am happy to point out that UNESCO has also been associated with the I.O.S.T.E. since it held its first Symposium in Canada. In the present case, UNESCO has also provided direct and indirect financial assistance to bring active science and technology educators to Kiel to participate and share their ideas and experience in the Symposium.

Ladies and gentlemen, the significance of the tasks ahead of you in the coming week or so can never be overemphasized. During recent decades, science and technology have made tremendous progress. Their values as a way of investigating and solving problems as well as enhancing decision-making in our daily life is now increasingly recognized. There is thus an urgent need to initiate students to the scientific spirit and to introduce them to a world made of technological objects and processes. We must establish in them a positive attitude towards science and technology in such a way that it is maintained and continued into their adult life.

In bringing you together, the organizers of the Symposium in particular Dr. RIQUARTS have provided an important forum for the exchange of experience in new developments and trends in science and technology education, and I take this opportunity to wish you a great success in your deliberations and hope that the co-operation established through personal contacts will go a long way in strengthening the Network on the subject and meeting the future challenges facing science and technology education. I am touched by the warmth of your hearts the collective warmth and cooperative spirit will help to change the otherwise cold weather into a warm and congenial athmosphere for achieving the objectives of the Symposium.

2 INTRODUCTION

Kurt Riquarts:
Introductory remarks to the 4th International Symposium on World Trends in Science and Technology Education

Frame and Theme of the Symposium

In cooperation with the Pädagogische Hochschule Kiel and the International Organization for Science and Technology Education (IOSTE), the 4th International Symposium on World Trends in Science and Technology Education was organized by the Institute for Science Education (IPN), Kiel, and held 4 - 12 August 1987 in Kiel, Federal Republic of Germany.

It was attended by 211 participants from 53 countries, which represented a substantial increase in comparison with the last symposium in Brisbane (Australia), particularly in the number of participants from abroad. Many more colleagues would have liked to attend but were unfortunately prevented by financial reasons.

The participants' professional background may be classified as follows:
- Teacher educators and subject specialists at universities and colleges (approx. 30%)
- Leaders of school-based curriculum projects (approx. 50%)
- Schools inspectorate and ministerial staff (approx. 20%).

As proposed by IPN and agreed on by the IOSTE committee and the General Assembly at the 3rd Symposium (Brisbane 1984) the theme of the 4th Symposium was: "Science and technology education and the quality of life".

This topic was a consistent extention of the themes of previous symposia: Halifax in 1979 was dedicated to Science Education, in Nottingham in 1982 Technology Education was included, and in Brisbane (1984) Society was added as a third aspect.

Science and technology was related to the quality of life with respect to
(a) the impact on everyday life situations
(b) decisions a responsible citizen has to make when dealing with (controversial) societal issues
(c) the impact on future careers.

Three main working groups dealt with these three areas from the point of view of
(a) science education
(b) technology education
(c) science, technology and society (STS).

104 scientific papers were accepted by the organizers and were published before the symposium in two volumes:
Kurt RIQUARTS (ed.):
Science and technology education and the quality of life.
Vol. 1: Science Education
Kiel: IPN, 1987 (ISBN 3-89088-018-5)
Vol. 2: Technology Education; Science-Technology-Society
Kiel: IPN 1987 (ISBN 3-89088-019-3)

The tables of contents for these two publications are given in section 8.

The thematic continuity of these symposia on World Trends in Science and Technology Education requires a similar continuity in the selection criteria for contributions. It was therefore decided to adopt the criteria agreed upon in Brisbane (1984), which seemed the best way of ensuring goal-oriented discussions and of being able to present as many useful ideas as possible.

We found most of the papers which could not be accepted nevertheless of great interest: they had simply been submitted to the wrong conference.

The widespread international response to the call for papers gives IOSTE and the symposium organizers reason to believe that the proposal to tackle Science and Technology Education and the Quality of Life was a step in the right direction which met the needs of many science educators and administrators.

And the fact that the International Council of Associations of Science Education (ICASE) chose the same theme for its symposium during the 1988 Australian bicenterary celebrations, knowing that it would be the subject of the 4th IOSTE Symposium in 1987, strengthens our conviction of having made the right choice. We hope that this volume of conference proceedings will stimulate the ICASE symposium, which is an excellent opportunity to take up good ideas and compensate for any shortcomings at the IOSTE meeting.

The structure of the symposium

Obviously, it would have been impossible for such a large number of papers to be read at the symposium. The papers were therefore presented through discussion in the various sessions of the working groups in accordance with the agreed structure. The details were conveyed to the contributors before the conference by the chairpersons of the main working groups.

Accordingly, all 104 accepted papers were categorized and each was assigned to
- one of the three main working groups,
- the content areas a - c.

1. Plenary sessions

On the basis of experience at the previous symposia, it was decided to limit the number of plenary sessions to five, namely:
- A general introduction to the theme of the symposium as part of the opening session (see chapter 3.1)
- An introduction to each of the three thematic areas of the symposium (see chapter 3.2 - 3.4)
- An evaluative summing-up at the close of the symposium (see chapter 6.1), and a generalistic view on the symposium and final recommendations.

2. Workshops and poster sessions

Two afternoons were reserved for workshops and a further 2-hour block for poster sessions. This provided an opportunity to pool practical experience in the teaching and learning of science and technology. Brief details of the design and brief reports of the poster sessions and workshops, many of which were held twice to satisfy demand, are given in chapter 4.

The main emphasis was on aspects of the following:
- technology education
- environmental education
- bio-technology
- computer in science/technology education.

3. Main working groups

As mentioned, the accepted papers were each assigned to one of the three main working groups. In a preparatory meeting held at Kiel in April 1987 the International Advisory Committee and the Organizing Committee of the symposium established the following structure for the three main working groups (according to the context areas set out above):

Science Education

1. Trends in science education
   (a) Developing world
   (b) Developed world

2. Everyday life
   (a) Educational development for science in everyday life
      - Indigenous science
      - Health and informal science
   (b) Improving the quality of science education
      - Integrated science
      - Recent demands

3. Responsible citizenship
    (a) Science for the community
    (b) Contributions of science education to citizenship
        - Chemistry
        - Geosciences and physics

4. Careers
    (a) Career choise
    (b) Career training

5. Teacher education
    (a) Instructional strategies
    (b) Concept and skill development

Technology education

1. Educational framework for school technology
2. Everyday life
3. Responsible citizenship
4. Careers

Science, Technology and Society

1. STS programs
    (a) Environmental STS programs
    (b) Other STS programs

2. Everyday life
    (a) Evaluation
    (b) STS courses/issues

3. Responsible citizenship
   (a) The student and STS
   (b) Critical analysis of STS

4. Instruction

5. Teacher education

The fact that three parallel groups were working on basically the same topic, though approached from different angles, made it necessary for each group to report as promptly as possible for the benefit of the parallel groups. Rapporteurs were therefore appointed for each session, who prepared brief reports to appear in the symposium's daily newsletter. These synopses also served as a basis for the general reports of the three main working groups presented in the plenary session at the close of the symposium. A revised version of these is given in chapter 5.

Acknowledgements

The organization of a symposium of this kind would be impossible without help from many sources.
Our special thanks are due to the following
(a) for generous financial support:
- United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris
- General Foundation for International Development (DSE), Bonn
- German Academic Exchange Service (DADD), Bonn
- Institute for Science Education (IPN), Kiel

(b) from the scientific point of view to all those whose contributions stimulated constructive and fruitful discussion

(c) for organizational support, to the many helpers from the

- International Advisory Committee
- Local Organizing Committee
- Staff members of IPN and the Pädagogische Hochschule, Kiel.

3 KEYNOTE ADDRESSES

3.1 Dieter Nachtigall: New priorities in science and technology education. A generalistic introduction into the theme of the symposium

Fragmentation and wholeness

It is my concern in this keynote address to make you aware of a problem that was recognized a few years ago mainly by the British theoretical physicist David BOHM in his book 'Wholeness and the Implicate Order'[1]. There you can find a chapter entitled 'Fragmentation and Wholeness'.

It seems to me that BOHM's thoughts expressed in this chapter are of fundamental importance for the mankind's working together for the common good and even for survival and that we, the teachers of science and technology, should draw conclusions for setting new priorities in our education of teachers at universities and colleges and of pupils at schools.

BOHM states that the life of an individual as well as that of societies is characterized by what is called 'fragmentation'. What does this mean? Everybody distinguishes between the self (the ego), and the reality outside, e.g. the family, the inhabitants of the house, the street, the village, the state, the country, members of different professions, sportclubs, religions, civilisations, political parties, military blocks, economic groups, lovers of classical music, disco sound, rock performances, representatives of the humanities, the sciences, technology etc. It turns out that we all are mentally determined by a kind of thought process that treats all things, events, phenomena, processes in ourself, in the societies and in nature as inherently divided. Everything seems to be disconnected and broken up into small constituent parts which are considered to be essentially indepedent and self-existent.

David BOHM describes the situtation as follows[1]:

> "Man's natural environment has correspondingly been seen as an aggregate of separately existent parts, to be exploited by different groups of people. Similarly, each individual human being has been fragmented into a large number of separate and conflicting compartments, according to his different desires, aims, ambitions, loyalties, psychological characteristies etc. ...
> The notion that all these fragments are separately existent is evidently an illusion, and this illusion cannot do other than lead to endless conflict and confusion. Indeed, the attempt to live according to the notion that the fragments are really separate is, in essence, what has led to the growing series of extremely urgent crises that is confronting us today. Thus, as is now well known, this way of life has brought about pollution, destruction of the balance of nature, over-population, world-wide economic and political disorder, and the creation of an overall environment that is neither physically nor mentally healthy for most of the people who have to live in it. Individually there has developed a wide-spread feeling of helplessness and despair, in the face of what seems to be an overwhelming mass of disparate social forces, going beyond the control and even the comprehension of the human beings who are caught up in it."

Fragmentation has many aspects.

Among others, C.P. SNOW's article in 'New Statesman' in October 1956, entitled "The Two Cultures"[2] which is still under discussion(e.g.[3]) is one of the aspects of this fragmentation.

There is, however, no doubt that it has always been necessary, proper and successful for man in his thinking and in his doing to separate things, to isolate phenomena, to reduce the number of parameters and to divide processes into smaller, more manageable proportions.

In ancient times there was the fragmentation into heavenly and earthly matter. Later, in NEWTON's times, it became essential to distinguish the centres toward which the matter was attracted.

The birth of the so called scientific method with GALILEI's approach to the problem of motion is perhaps the most inpressive example of the power of fragmentation, of the efficiency of reductionism. Instead of seeing exclusively the whole of the process of the motion of a thrown stone, including the question of why the object moved, he restricted himself to the problem of how it would move (under idealized conditions). He separated or 'fragmented' in his thoughts the process into two separate motions, one being an unchanging, unaccelerated horizontal translation, the other being a vertical, accelerating motion, obeying the laws of free fall. These two components do not impede or interfere with each other.

GALILEI's scientific method became the root of research methods in the natural sciences. It was also adopted to a large extend by the social sciences and has influenced strongly theory and practice in almost all fields of human concern, be it politics, economics, military, art and even human consciousness.

On the other hand:

> "... man lost awareness of what he was doing and thus extended the process of division beyond the limits within which it works properly. In essence, the process of division is a way of thinking about things that is convenient and useful mainly in the domain of ractical, technical und functional activities.... However, when this mode of thought is applied more broadly to man's notion of himself and the whole world in which he lives (i.e. to his self-world view), then man ceases to regard the resulting divisions as merely useful or convenient and begins to see and experience himself and his world as actually

> constituted of separately existent fragments. Being guided by a fragmentary self-world view, man then acts in such a way as to try to break himself and the world up, so that all seems to correspond to his way of thinking. Man thus obtains an apparent proof of the correctness of his fragmentary self-world view though, of course, he overlooks the fact that it is he himself, acting according to his mode of thought, who has brought about the fragmentation that now seems to have an autonomous existence, independent of his will and of his desire"[1].

In this way the myth is established that the content of our thought can stand for a description of the 'world as such', that our theories are a form of knowledge of 'how the world really is' whereas theory and concepts are primarily a form of insight, a way of looking at the world, and splittings, differences, distinctions, separations and idealizations as guides give isolated perception "wich is shaped by fragmentary thought"[1].

Every scientist knows that theories are changing permanently. Therefore, our 'pictures of the world' are ever-changing forms of insight. They give shape and form of what we call experience. Thus, necessarily, our vision is always limited and our insights are prevented from going beyond limitations. Our approach to nature, society, and the individual takes place "... in terms of more or less fixed and limited forms of thought", and we "... keep on confirming the limitations of these forms of thought in experience"[1].

What is the result of this human behaviuor? According to BOHM an illusion!

> "We will thus be led to the illusion that the world is actually constituted of separate fragments and... this will cause us to act in such a way that we do in fact produce the very fragmentation implied in our attitude to the theory... Wholeness is what is real... and ... fragmentation is the response of this whole to man's action...

> In other words, it is just because reality is whole that man, with his fragmentary approach, will inevitably be answered with a correspondingly fragmentary response"[1].

And then comes the sentence which is - to me - the most important of this article, because it implies the very basis of the new priorities for science and technology teachers which I'm going to present:

> "So what is needed is for man to give attention to his habit of fragmentary thought, to be aware of it, and thus bring it to an end. Man's approach to reality may then be whole, and so the response will be whole"[1]

We may have any number of different kinds of insight. All our different ways of thinking are different ways of looking at the one reality,

> "...each with some domain in which it is clear and adequate. One may indeed compare a theory to a particular view of some object. Each view gives only an appearance of the object in some aspect. The whole object is not perceived in any one view but, rather, it is grasped only implicitly as that single reality which is shown in all these views. When we deeply understand that our theories also work in this way, then we will not fall into the habit of seeing reality and acting toward it as if it were constituted of separately existent fragments corresponding to how it appears in our thought and in our imagination when we take our theories to be direct descriptions of reality as it is"[1].

The atomic theories illustrate this in an impressive way. Democritus, Thomson, Rutherford, Sommerfeld, Bohr, de Broglie, Schrödinger, Heisenberg, Dirac and other names represent different fragmentary views with increasing grades of abstraction, so that finally models were developed which are just sets of equations. These reflect aspects of atoms which are not represented by pictural 'forms of insight'. These and various other patterns, developed mainly in the most modern theories on the basis of relativity and quantum mechanics, imply the need to look on the world as an undivided whole. All parts of the universe, the observer and his measuring equipment included,

"...merge and unite in one totality"[1].

There are further approaches. One of them is a new form of insight, called 'Undivided Wholeness in Flowing Movement' the essence of which is that not only energy and matter but also matter and mind are not separate substances.

> "Rather they are different aspects of one whole and unbroken movement. In this way, we are able to look on all aspects of existence as not divided from each other, and thus we can bring to an end the fragmentation..."[1].

But this is beyond the framework of my concern today. Let me come back to education of pupils at schools and of teachers for science and technology at colleges and universities.

They should be aware that man beside his fragmentary approach has always been seeking wholeness. NEWTON was able to connect falling apples and planetary motion, MAXWELL combined electricity and magnetism. BOLTZMANN and GIBBS have put together mechanics and heat, EINSTEIN unified mechanics and electrodynamics. In this decade quantum field theory is being used as a framework for unification in such a way that particles are quantum exitations of matter, and electromagnetic, weak and strong interactions become just aspects of a unified theory. However, many questions still remain.

The tendency of man to look for symmetries, to use symmetry as a tool to gain insight into physical situations, his preference for symmetrical patterns, e.g. in architecture, in crystallography, in solid state physics, in optics, in the arts (Escher), the usage of conservation laws as 'clamps' of the chaotic multitude of singular facts and symmetry principles in modern physics, (matter-antimatter-symmetry, quark-lepton-symmetry) is one aspect of this tendency.

But the desire to seek wholeness became manifest not only in the sciences. Man always had the feeling that wholeness or integrity is necessary also to make life worth living, be it mentally, physically, socially or individually. The yin-yang-concept for example, assumes two opposite but complementary forces. In man their equilibrium governs moral and physical health. Therefore,

- if - on the one hand - fragmentation is an almost universal habit of mankind to explore and to handle nature,
- if this habit just leads to limited forms of insight, which, considered as copies of 'reality as it is' lead to a sort of self-mutilation of man's intellecutual and practical power,
- and if, on the other hand, seeking wholeness is necessary to make better sense of the world, to facilitate the living-together of mankind and, perhaps, to ensure the survival of mankind in dignity,

then this item must be a subject in schools. But before this can be, it must get priority in the field of teacher education:

The wholeness - approach, as I call it for short, has many practical aspects. I consider three of them the 'new priorities' in the field of science and technology teacher education:

- Emphasis on moral values,
- Overcoming the fragementation in the school sciences,
- Insight into the effect of exponential growth.

Focussing on these three aspects is the result of my mental fragmentation schema. But, as said before, being aware of it facilitates the approach to the whole.
And, by the way, it will turn out that these three aspects are closely related. They could also be discussed under the headline 'wholeness in educaton'.

Emphasis on moral values

Scientific knowledge means power. The scientist seeks knowledge not with the intention to get power but with the desire to know.
But he is responsible for the consequences of the application of his knowledge, not in a legal but in a moral sense. Who else can better estimate the implications of scientific findings than the discoverer himself?
Not all consequences and implications can be overlooked and predicted and the scientist does not take the decision about the usage of his findings, e.g. for the developments of arms. But he must seek and use political influence to make sure that it is always possible to search for knowledge and seek for truth but that the applications of the outcomes of these activities are used for such limited purposes only that are for the benefit of mankind as a whole. This is the responsibility of the scientist and this is a demand not to his cognitive ability but to his moral qualification. School has the duty to deal with such problems. This means that mainly teachers of science and technology must be prepared to discuss such questions in the classroom. Therefore, lessons in science and technology should also implement moral aspects. Values should be discussed. However, in most schools, the teachers focus on subject knowledge only. They consider education as transfer of unconnected portions of facts so

that these fragments appear to substitute for the whole. Fragmentation reveals here its worst aspect. It restricts the spectrum of perception of reality.

Therefore, the establishment of a feeling for the need of morality and values is the key priority for science and technology teachers.

What is morality? It's a set of principles, virtues and attitudes recognized by a group or institution, serving as a guide on how a man should live.

The existence of such guidelines creates in the individual trust in the members of the group or the institution which in turn inclines him to more cooperation, more honesty, to make better sense and to give purpose and meaning to his life. As the practical 'operational elements' of morality appear the values. Without values there is no politics, no goals, no programmes, no strategies. Threat of the own value system motivates us to learning and to actions. Values are always connected with feelings and emotions.

To me the established injustice of the behavior of the First World vis a vis the Third World, the unjustified difference between the rich and the poor, the arrogance of the privileged against the unprivileged is an truth that demands changes, claims justice, asks for solidarity. That's the reason why I try to go every year for a couple of weeks to a developing country - the Philippines - in order to help this country in the field of physics teacher education and to change my own attitude as a privileged individual. Unjustice ought to be reflected by the mirror of morality which in turn must be formed in the minds of all people in the East, West, North and South. This can and must be done in the schools. The questions of goodness or badness, praiseworthiness or blameworthiness, rightness or wrongness should be answered in the global sense of priority of the happiness and well-being of mankind in general, not of prosperity, dominance or power of a praticular nationality, race, religion or ideology. What ought or ought not to be done is not only a question for philosophers but should rather become the subject of everybodys thought.

The people - not only the philosophers - should ask themselves "What will be the outcome of my doing?"

and

"What would happen if everyone did that?"

and

"Does it in its tendency promote absence of hunger, sickness, pain, feeling of suppression, unjustice, violence? Does it reduce danger of war, does it help to stop the destruction of nature and the blind plundering of nonrenewable resources?"

As said before: Fragmentation means restriction of perception of the reality. On the face of this phenomen we observe that scientists are mainly focussed on the number of their publications, technicians on the number of their patents, politicians on the number of their voters in the next election, managers on the growth of the export rate, military people on the number of megatons TNT and the possible number of megadeads etc. A sense for morality can hardly develop. Here are some examples of immorality that frighten me and that are to my opinion not only subject of private feelings but educational elements of human conduct in general.

In the Second World War the Germans had occupied Poland. The German Governor Frank was residing in Cracow. According to his own words he was responsible for the murder of 150.000 Polish people[4]. After his flight from Cracow in January 1945, Bishop Hudal in Rome offered him a flight trail to a nazi - friendly country in South-America. This support of a nazi-criminal by an official of the Catholic Church is - to me - unmoral behaviour.

On April 26,1986, at half past one in the night, the nuclear accident at Chernobyl happened. In the evening of April 28, i.e. about 60 hours after the event, the general public of the Earth was informend, not by the Soviet Union, but by Swedish authorities. Only after furious demands for information from Sweden and other Western Countries did the Soviet Union even admit that anything had occured, and then they limited themselves to vague statesments with the result that anxiety over the nature and extend of the accident increased. It must be stated that it will take decades before all the effects of this worst nuclear accident on both people and the environment are known. In the view of this fact a policy in which official failures are not acknowledged, in which official sins are not recognized, in which potential danger to all people on earth in considered insignificant versus national prestige is - in my view - non-moral.

Every year on July 20 we remember in Germany the attempt upon Hitler's life in 1944, undertaken by a group of the German resistance. Every year also members of the German Gouvernment address this event, one of the very few in this century we can be proud about. The officials talk about the right of violence against dictators, against authorities which themselves violate elementary human rights. Nearly simultaneously there was another debate about human rights. In Chile, at present at least 9 people face death penalties because they have been fighting in the underground against the dictator of this country. Several of these people have been tortured. When in a country torture is common and the police are murdering, then the judicial power of the country is not credible at all. Nevertheles, the German Minster of Internal Affairs refused to agree that these victims get asylum in the Federal Republic, which would safe their lives. This is - in my opinion - double morality an this means dishonesty.

In the United States there was in the last month a man, Oliver North, triumphing by defiantly admitting lies.

He represents - in my view - falsehood and deceit, ruse and malice, even willingness to violate the constitution.

A Rambo as a diplomate,
a swashbuckler as a national hero,
a macho-swagger as an American icon...[5,6,7]

all this causes in my mind the need to ask about standards of the moral qualification and credibility of the administration of this superpower.

Interpersonal relations are the decisive element of the teaching-learning process. They develop mainly on the basis of mutually respected values. The teacher should neither impose nor hide his own value system, and my students know about my standpoint in terms of responsibility of the scientist in the society as well as in terms of morality in politics.

All this has to do with fragmentation and wholeness. Today it is widely accepted that there is a strong mind-body interaction which can be measured by objective means. This is not only of philosophical interest. It becomes more and more accepted that in the medical profession it is not sufficient to treat desease on a purely physiological basis.

One of the findings of brain research is - recognize the method of separation and fragmentation - that one hemisphere of the brain is the intellectual part and the other one is the emotional part. However, between these two parts there is a large number of nervers crossing the border. Every thought affects the emotions, every emotion comes up to affect the thought. There is no thinking without the emotion of wishing to think. It depends on the kind of desire in which direction the thought will go. Thought produces images and images generate feelings. Thus emotions are profoundly affected by thought. Thoughts of horror may produce the same emotions as the perception of actual horror.

If one wants to try to look at nature as a whole, one has to use emotions as well as the intellect. We should think about feelings in our science and technology classes and we schould develop feelings, emotions and values by means of thinking about our subjects.

All this can be justified by the fact that the world's immensity in a good and in a bad sense creates feelings. People feel happy, excited, fascinated and lucky and they get angry, exalted, scared and bored in turn. And does not the rush for money, the greed at maximum profit, the misuse of power, the propensity for dominance, the lack of good political will influence the state and the fate of our world much more than scientific thought, objective reasoning and logical interference?

EINSTEIN, when he spoke about interpersonal human relations, expressed his concern on

> "...fulfillment on the moral and esthetic side... Understanding of our fellow-beings is important. But this understanding becomes fruitful only when it is sustained by sympathetic feeling in joy and sorrow... Without 'ethical culture' there is no salvation for humanity"*.

Overcoming the fragmantation of the school science

Nobody in this audience will doubt that the sciences are a necessary school subject and that the young generation should become familiar with technology. But why do we consider science and technology to be important?

Science and technology stamp this century. Evidences for success and landmarks of hope can be seen in many respects:

- the mortality of babies is falling
- the human life expectancy is increasing
- the proportion of world's adults who can read and write is growing
- the proportion of children starting school is rising
- the global food production is climbing
- the strain of physical work is - in the average - decreasing
- the availability of useful information, the opport unity to watch exciting events like Olympic Games or Football World Championships, has been made accessible to billions of people.

All these achievements were possible due to research and development, science and technology.
The memory of how the people of the world suffered without science is soon lost and young people never know.
However, we must see the whole. We must take into consideration negative side effects, unwanted developments, harmful trends, dangerours aspects, with other words: we must recognize the effects of fragmentation and have to realize that

- in terms of absolute numbers there are more people starving nowadays than ever before
- the absolute number of these people is increasing
- the same is true for people who can't read and write

- the absolute number of those without safe water (bad water being the cause of 80 % of all deseases in Third World Countries) is growing
- the absolute number of those who are short of wood-fuel with which to cook and warm themselves is climbing
- three out of four babies are born nowadays in Africa, Asia and South America; thirty years ago it were two out of three and in 2020 it will be four out of five
- most of these Third-World-Babies will belong to the poor of this earth and this means that the world of 2020 will be a world of the poor, and poverty as the 'most effective' form of violence against the masses will spread
- the poor of today and those of tomorrow are and will be not poor because they have so many children, but they have and will have so many children because they are poor
- to have many children plays in these regions the same important role as pension, life insurance, saving account and possession of real estate play in developed countries
- the more prosperous a society is, the better the chance of the decrease of the birth rate and vice versa
- the population pressure in Third World Countries will be the reason that economic progress will be eaten up by the rapidly growing population; people there will continue to suffer from hunger and poverty and the political tensions between the rich North and the poor South will grow

- the economic politics of industrial countries of buying raw material at low prizes from Third World Countries and selling industrial goods back to them at high prizes has created a debt crisis that can lead to the collapse of the world's monetary system
- ruthless protectionism followed by worldwide regression and galopping unemployment in industrial as well as in developing countries may cause uncontrollable social tensions and civil wars, may endanger existing democratic systems and strengthen dictatorial tendencies
- the mutual fragmentary perception of the leaders of the superpowers is very dangerous for world-peace
- the tendency to realize what is technically possible i.e. to see technique not as a mean for a reasonable purpose but as an end in itself, is untechnical and morally blamable
- environmental degration clouds the vision - mainly of the young generation - of a common life-worth future
- research and development, science and technology - and this is what we have to realize - have given mankind the power to destroy itself.

Research and development, science and technology are the most powerful tools to make the well-being of mankind on Earth possible. But they are also the most dangerous instruments for the suicide of mankind. Global interdependence is the central reality nowadays. To solve the main global problems requires a redefinition of priorities, natinoally and globally, and this is possible only on condition that a new thinking takes place that makes it possible to eliminate - in the long term - political, military, economic, religious and environmental sources of conflict on the basis of a new global morality. Then the monetary sources of the nations of the world could be used to overcome the threatening developments. The main source of money to turn off the suicidal danger is the sum of todays national military budgets.

In 1986 the world spent more than $ 900 billion on military purposes. This means $ 2.5 billion per day or $ 100 million per hour. In the time required to say the word 'ninehundred' on the averge $ 270,000 are spent.
Here are some examples of what the same resources might otherwise be used for*:

- Actions for the establishment of the possibility of wise usage of tropical forests would cost $ 1,3 billion a year over a course of five years. This annual sum is the equivalent of half a day of military expenditure worldwide
- Implementing the UN Action Plan for desertification would cost $ 4,5 billion a year during the last years of this century. This is the equivalent of less than two days of military spending
- Providing Third World Countries with clean water on the basis of a UN Water and Sanitation Project would cost $ 30 billion for a decade. This is approximately equivalent of 12 days of military spending
- To supply contraceptive materials to women already motivated to use family planning would cost - in addition to $ 2 billion spent today - an additonal $ 1 billion per year. This additional $ 1 billion is the equivalent of 10 hours of military spending.

You think this has nothing to do with teaching sciences and technology in schools? All this does not belong to the syllabus? All this 'pollutes' our teaching of objective subject matter? To a physics teacher just the teaching of the contents of the textbook is what he should do?

Again EINSTEIN's opinion may be helpful:

> "It is not enough to teach man a speciality. Through it he may become a kind of useful machine but not a harmoneously developed personality. It is essential that the students acquires an understanding of and a lively feeling for values. He must acquire a vivid sense of the beautiful and of the morally good.
> Otherwise he - with his specialized knowledge - more closely resembles a well trained dog than a harmoneously developed person"[18].

This means that teaching physics does not only mean teaching physics subject matter. And it is also not enough to introduce in the orthodox physics textbook and in physics classes a 'moral component'.

The wholeness-approach requires to try to overcome as far as possible the fragmentation of subject matter in the school curricula. I remember a lecture of the late Roman SEXL, one of the most remarkable physics educators. He caricatured the result of fragmantation in school physics and school chemistry in the following way:

- In physics pupils learn about Bohr's atomic model. Atoms in physics are flat. They consist of some concentric circles with a few tiny billard balls in the center.
- In chemistry the pupils learn about the orbital model. Atoms in chemistry are three dimensional. Characteristic is a spherical or a dumpball shape.

Therefore, with physical atoms one can make flat things, like sheet of paper, tesa film etc. With chemical atoms more or less round things can be made, like footballs, bulbs etc.

How can we overcome the isolation and departmentalization in the school sciences? Physics, chemistry and the other sciences must be seen as integrable constituents of an integrated whole and connected with technology, social sciences, art etc. There are projects and books, ideas and attempts. But is there a consequent and consistent approach that covers in a didactical order (table I) scientific aspect of world understanding, starting with the concepts of physics, running through the more and more complex fields of what in the orthodox classification is called earth science, chemistry, biology, ecology, life science and cosmology with investigations of isolated and complex phenomena? I don't know. But it should be done in this or another mode and it should be embedded in a comprehensive framework such as sketsched in table II. This is my idea of an approach to the whole. One should start with a corresponding teacher education. I know how hard this will be. Old habits die slowly.

Insight into the effect of exponential growth

Why do I count this item to the three priorities in science and technology teacher education? Because there is a conflict between exponential growth and a finite environment. Students learn in mathematics lessons the arithmetic of this function. But fragmentation prevents the application of this idea to phenomena that are vital to each individual as well as to mankind as a whole. A.BARTLETT wrote an article, 9 years ago, for American Journal of Physics[11]. The essence of this publication is that the greates shortcoming of the human race is

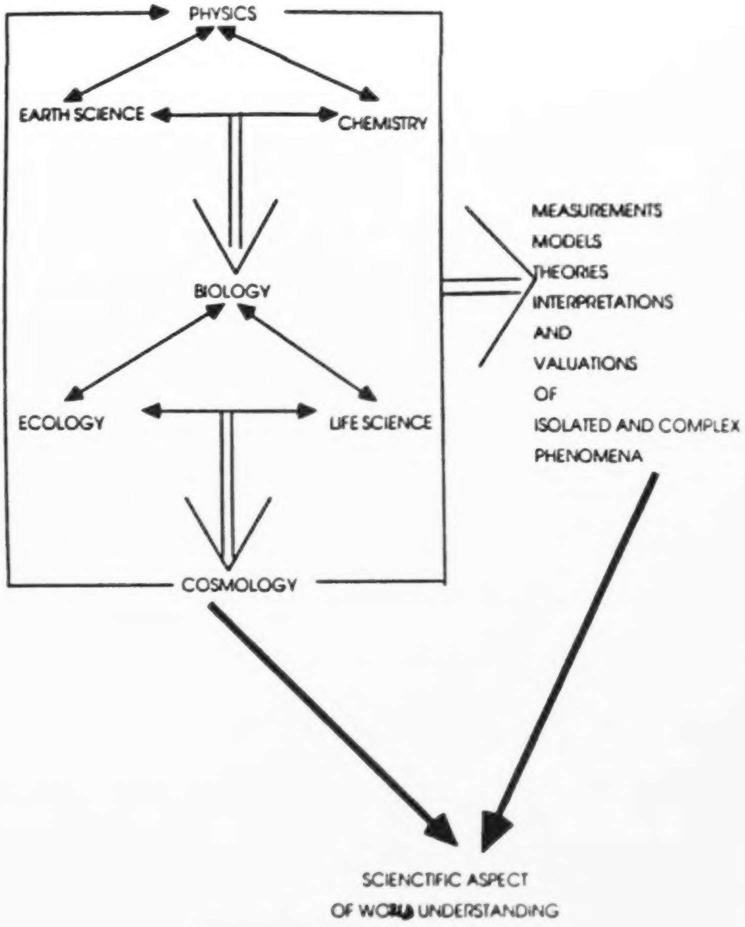
PHYSICS
EARTH SCIENCE
CHEMISTRY
BIOLOGY
ECOLOGY
LIFE SCIENCE
COSMOLOGY
MEASUREMENTS
MODELS
THEORIES
INTERPRETATIONS
AND
VALUATIONS
OF
ISOLATED AND COMPLEX
PHENOMENA
SCIENCTIFIC ASPECT
OF WORLD UNDERSTANDING

Table I

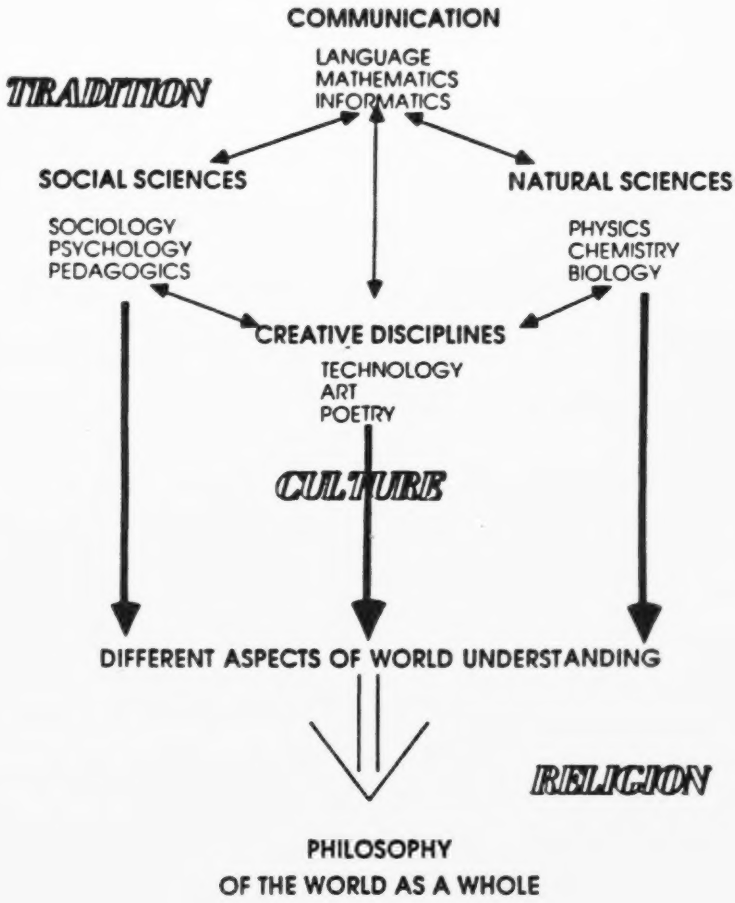
COMMUNICATION
LANGUAGE
MATHEMATICS
INFORMATICS
TRADITION
SOCIAL SCIENCES
SOCIOLOGY
PSYCHOLOGY
PEDAGOGICS
NATURAL SCIENCES
PHYSICS
CHEMISTRY
BIOLOGY
CREATIVE DISCIPLINES
TECHNOLOGY
ART
POETRY
CULTURE
DIFFERENT ASPECTS OF WORLD UNDERSTANDING
RELIGION
PHILOSOPHY
OF THE WORLD AS A WHOLE

Table II

our inability to understand the exponential function. I`ll show with some examples that this statement contains more than a grain of truth and I will demonstrate that the exponential function can be made understandable quite easily to almost everybody who reaches the level o a ninth-grader.

An interesting and important property of the exponential growth is that the time required for the growing quantity to increase its size by a fixed fraction is constant. In the same time there is always an increase of the same percentage. The time for 100 % increase, the doubling time T_d, is of special importance and extremely useful for everybody.

We describe exponential growth by the equation

$$N = N_0 e^{\lambda t}$$

where λ is the rate of increase of the quantity N_0. New let's ask for the doubling time T_d. In this time the quantity N_0 has doubled, so that

$$2 N_0 = N_0 e^{\lambda T_d}.$$

Now we take the natural logarithm of each side and get

$$\ln \frac{2 N_0}{N_0} = \lambda T_d$$

$$\ln 2 = \lambda T_d$$

$$T_d = \frac{\ln 2}{\lambda} = \frac{0.693}{\lambda}$$

If we express λ in percent, then

$$T_d = \frac{69.3}{\text{rate in \%}} \approx \frac{70}{\text{rate in \%}}.$$

Another important fact of exponential growth is that the doubling of consumption of something in e.g. ten years means that in these ten years there will be more consumed than the total previous consumption. This, if the consumption grows exponentially from the beginning, can be made clear by means of the well known problem of filling the squares on a chessboard in such a manner that 1 grain of rice is put on the first square, 2 grains on the second square, 4 grains on the third square and so on; always the next gets twice as much as the predecessor.

Before one puts 4 grains on the third square, the total number of grains is 4 - 1 = 3. Before one puts 32 grains on the sixth square, the total number is 32 - 1 = 31, etc.
It is surprising and against our intuition that e.g. an exponential growth of car production of 'only' 7 % per year would mean that in the next decade more cars would be built than in the entire history of the automobile industry up to now. It's also against our intuition that 'only' an annual growth rate of about 10 % was needed for the increase of the population of Bogota from 1 to 7 million within 20 years.
In 1975 the population on earth was estimated to be $4 \cdot 10^9$ people. This means a growth of 1 billion in 12 years, because last month the 5 billionist inhabitant of the earth was born.

It is easy to calculate the average growth rate in these 12 years:

$$N = N_0 e^{\lambda t}$$

$$\frac{5 \cdot 10^9}{4 \cdot 10^9} = 1.25 = e^{\lambda \cdot 12}$$

$$\frac{\ln 1.25}{12} = \lambda = 0.00186 \text{ or } 1.86\ \%.$$

In 1984 the growth rate of the population of the USA was 0.7 %. This means a doubling time of about 100 years. For Mexico the growth rate is at present 2.6 % and the doubling time is

27 years. In Kenya they have a 4.0 % growth rate and a doubling time of 17.5 years. At present the growth rate in the Federal Republic of Germany is about zero.
In China the population in 1945 was 400 million. It's now, 42 years later, 1 billion. Assuming an increase with constant rate this means that China had in the past a growth rate of 2.18 %. It is said that the population will increase only up to 1.2 billion until the end of the century. This means that the growth rate will drop to 1.40 %. Is this the solution of Chinas population problem? Hardly! It means that the doubling time is then 50 years and not 32 years. The solution can only be to strive consequently for a zero growth rate.

The dry land surface area of the earth is 150 million square kilometers. Nobody can imagine that it would be possible to live with a population density of 1 person/m^2 . But with todays growth rate of 1.86 % we would get this density rather soon:

$$1.5 \cdot 10^{8}\ \mathrm{km}^2 = 1.5 \cdot 10^{14}\ \mathrm{m}^2$$

$$1.5 \cdot 10^{14} = 5 \cdot 10^{9} \cdot e^{0.0186\, t}$$

$$\ln \frac{1.5 \cdot 10^{4}}{5 \cdot 10^{9}} = 0.0186\, t$$

$$t \approx 550 \text{ years.}$$

This means that in 18 generation this horror vision would be reality if the exponential growth is not be stopped. It is obvious that very soon the population growth must be reduced to zero. If we today hesitate to attack this problem, we leave it under even more complicaded circumstances to the following generations. If the world's growth rate of 1.86 % remain constant, then the population of the earth will be 10 billion within the doubling time

$$T_d = \frac{70}{1.86\ \%} = 38 \text{ years.}$$

In the year 2000 the earth would (will?) have 6.4 billion, in the year 2025 the earth would have to bear and to endure 10 billion people. In ancther 38 years the population would double again so that in 2063 the earth's inhabitants would amount up to 20 billion.

It is self-evident that in this connection also the exponential decay rate and the term half-life T_h must be discussed. The half-life of Plutonium -239 ($2.41 \cdot 10^4$ years) is an impressive example. Consider, as a model, the growth of a special species of living micro-organisms (LMO) somewhere in a desert.

The LMO's are able to live only on a palm tree that offers them all their requirements for reproduction by division and for survival. Suppose the doubling time of the LMO's is 1 day. This means steady growth, exponential increase. The first LMO was placed somehow on the palm tree on August 5, 1986. After one day, on August 6, 1986 there were two LMO's, one day later four LMO's and so on. Because they are micro-organisms a lot of them have space on the palm tree. Here we simulate in a thought experiment the exponential growth in a finite environment. The LMO's live and reprocudce for nearly one year and to them everything is o.k. But with increasing population also social life has been organized. The LMO's have their economic, political and educational system and they have also research, technology and philosophers, i.e. creatures which the human species sometimes call egg-heads. These egg-heads discover that some day the community may run out of space. They propose a research program which shall start on August 1, 1987. At this time only 6 % of the palm tree area is occupied by the LMO's. Therefore, the politicians resist, hesitate to grant money because 94 % of the palm tree is still unused space, enought for - in their view

- unlimited time. But finally the egg-heads succeed and start their program on August 2, 1987, one generation after the placement of the proposal. Now 12 % of the palm tree area is occupied; for the politicans still no reason to worry. Luckily, on August 4, 1987, (50 % of the palm tree is now occupied) the researchers discover in their environment 3 new unoccupied palm trees.

This is three times as much as they had ever known. Due to this discovery they have now 4 palm trees insted of one, a tremendous enlargement of their living resources. They also know how to migrate to their new habitats.
Finally, on August 4, 1987, everybody is happy: the egg-heads feel that they are really useful, the politicians are proud that they have `saved` the society and everything seems to be in a good shape. But what happens really and what could have been foreseen by the egg-heads and by the politicians if they would have been able to understand the character of the exponential function?
One day later, on August 5, 1987, (today!!!), the original space of living is completely occupied. On August 6 (tomorrow!!), one of the three new palm trees is full, and on August 7 (Friday!!) everything is full, no resources are left and the LMO's will die out.
Now replace the LMO's in another thought experiment by human beings, the palm tree by the earth, and consider as living requirements coal, oil, space, clean air, unpoisoned water, soil which is not contaminated by radioactive material, forests that do not die due to carbonoxides and sulphurgases, and so on. In contrast to the LMO's on the palm tree, where neither the egg-heads nor the politicians understood the exponential function, within the human society the egg-heads understand this function very well. But unfortunately it seems that the politicians and other officials do not. Be it

the Pope with respect to the growth of population, be it national leaders who call e.g. for growth of the national coal production, be it the automobile-industry which wants to increase the car production permanently, be it the food refinement industry with its increasing consumption of energy and plant albumens for the production of meat - they all seem to follow the wrong myth that 'growth is good'. They never ask how long growth can continue. They preach that 'bigger is better' and forget that the earth is a finite system. They believe that 'everything must grow or we will stagnate' and do not realize that this ideology is as dangerous for the lives of future generations as Aids is nowadays for individuals. At the end of my presentation let me demonstrate drastically the exponential growth of liberated potential energy of a set of plexiglas-dominos of increasing sizes. The smallest one has the dimensions of roughly 1 mm X 5 mm X 12 mm. The next one has all dimensions increased by a factor of approximately 1.4. The dominons are placed in such a way that the longest side forms the vertical. The areas formed by the two longest sides face each other and the distance from one domino to the next bigger one is about one third of the longest side of the smaller of the two neighbours. The potential energy is proportional to the mass (this means to the product of the three side lengths) and to the height of the center of mass (this means again a length).

Therefore, the pontential energy grows from domino to domino with the fourth potency of the increase of the dimensions, i.e.

$$E_{pot} = 1.4^4 = 3.8$$

If the smallest domino falls against the neighbour, this one falls also and knocks down the next one and so on.

We have 13 dominos. This means that in 12 kicks we get an exponential growth of the amount of liberated potential energy by a factor about

$$3.8^{12} \approx 10^7$$

One should show this experiment to all those who have influence in society and who still think that the laws of physics can be put out of force when they are in contradiction to human unscientific dogmas. This will not work and nobody can fool nature.

I have discussed three aspects of the wholenss-approach. I give them the highest priority because I think they are extremely useful for the development of the self-concept of teachers and learners. The more highly developed the self-concept is, the better is a person equipped for a self-confident life as an individual and as a valuable member of his society.

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3 KEYNOTE ADDRESSES

3.2 Andrew O. Urebu:
Science and technology education and the quality of life: The impact on everyday life situations

Introduction

Why talk about the impact of science and technology on everyday life situations? Is the impact of science and technology not everywhere around us? Have the modes of thought, values and attitudes engendered by Western Science and technology not begun to permeate man's thinking than ever before? Is it not obvious that most poor countries in the world are in need of science and technology to improve their everyday life situations? Do these countries not try to overcome the stagnation built into their traditional lifestyles? Is it not to that end that industrialized countries must transfer their science and technology?

The above questions may seem rhetorical and perhaps need not be asked in the first place. But nowadays, things are changing and what is commonsense now is even being questioned. For example: Is the impact of science and technology on everyday life situations to be construed only in terms of Western lifestyles, standards, attitudes and values? What are the concerns of developing countries as it pertains to the impact of science and technology? Is transfer of technology always beneficial? How do advanced industrialized countries view the transfer of technology to developing countries? How can both rich and poor countries succeed in building an alternative science and technology which will permit cultural pluralism in science and diversification of technology?

These questions probably make clear the reasons why we must address ourselves to the impact of science and technology on everyday life situations at this symposium. Developments in science and technology have become, in recent years, important elements in world politics with widespread international economic and socio-cultural ramifications. Thus by "situating" science and technology within a broader political and socio-economic context, we get the 'real' impact of what is happening in our daily life situations.

Western View of the Impact of Science and Technology

First let us examine what is generally construed as the impact of science and technology in everyday life situations. These have been stated rather pointedly by the American Scientist, Emmanuel G. MESTHENE in his study on **Technological Change: its impact on Man and Society**[1] when he argues that "technological change is outstripping traditional methods of analysis in the same way as it is rendering obsolete many established institutions and values of society."[2] In short, he begins with issues very much like the ones concerning us here: How does science, and technology affect society? What are the value implications of technological change? What is the import of science and technology for the political organization of modern society?

MESTHENE sees technology as tools in a general sense, including not only machines but also including such intellectual tools as computer language and contemporary analytic and mathematical techniques. That is, he defines technology as the organization of knowledge for the achievement of practical purposes. It is in this broad context that we can best see the extent and variety of effects of technology on our everyday life situations.

From this broad context, MESTHENE outlines the full dimensions of the vast upheaval around us, clearly defining both its positive and negative aspects and argues for a response that will make man master rather than slave to science and technology. As he says:

> "modern technology-nuclear energy, rockets, computers, television, wonder drugs and the latest surgical techniques-affect society in important ways. The serve to bring about changes in institutions and individual lifestyles; they generate strains for our values and belief systems, and they create problems and opportunities for our economic and political organizations ... thus, for example industrial technology, that is new machines and processes and the advent of factory automation strengthens the economy as the measures of growth, productivity and living standards of Western societies show. However, these new machines and techniques of production also alter the amounts and kinds of materials, of parts of components of evergy, of labor skills and of supporting services. Instances of this kind of change in recent years have been the shift from coal to oil and natural gas for residential heating and the marked displacement of steel and tin by paper and plastic in the container industry."[3]

However, MESTHENE is quick at pointing out that these phenomena are nothing new and that new technologies had brought social changes since the beginning of time. The 18th century industrial revolution witnessed the invention of the steam engine and development of factories. What distinguishes the 20th century from the 18th century in this respect then is less the fact that technology has important consequences than our widespread awareness of that fact and our readiness to deal with it. This new awareness is the result of three factors.[4] As MESTHENE points out, the first factor pertains to our understanding of the nature and consequences of modern science and technology. Secondly, our adeptness as a society in the deliberate use of technology to achieve our goals; and thirdly, sheer population growth. The third factor seems the most potent of all. It is to technology in conjunction with population growth that we must look as we attempt to guage the nature, dimension and directions of contemporary social change, not to technology alone.[5]

Some advanced Western societies have developed social indicators to help guage the impact of science and technology. Some measure of success has been made on those bearing on the economy e.g. productivity and employment, inflation, expenditures, investiment, consumption and income distribution. Other areas where relative success have been made to develop social indicators to help determine the impact of science and technology include national health, employment opportunities, the state of the environment, the degree and location of poverty, the costs and effects of crime, the quality of the educational system, science and art and the degree and effects of participation in or alienation from public life.[6]

In sum what emerges from this picture is a situation where norms and techniques values and attitudes towards science and technology and what is happening in everyday life situations reinforce each other. The impact of science and technology is thus potrayed in terms of Western concerns i.e. lifestyles, standards, attitudes and values.

Science and Technology in the Third World (Developing Countries)

Now let us examine the impact of science and technology in the third world (developing countries), particularly those countries in Africa.

The impact of science and technology in developing countries has tended to bear on two opposing directions at once.[7] On the one hand Western science and technology is being sought virtually without limits: on the other, there is opposition to certain aspects of Western lifestyles, attitudes and values. In my initial paper on "Science and Technology Education and African Values" (prepared also for this symposium) I alluded to this, as the "techno-cultural gap" between values and Western science and technology.[8]

The questions thus arising is that: Is the impact of science and technology on everyday life situations to be construed only in terms of Western attitudes, lifestyles and values? Are indigenous cultures and value systems of developing countries to be demolished? What are the concerns of developing countries as it pertains to the impact of science and technology?

Indigenous Technology in Africa

There is a view that indigenous technological development was either non-existent or irrelevant to traditional African societies according to the myth of "primitive Africa". However this view is now being challenged and is not accepted by everyone.[9] Africa possessed a rich technological base on which a technological revolution and successful industrial development might have been achieved, but for the historical disaster of slavery - Africa was thus technologically castrated.[10]

Recent studies have documented pre-colonial indigenous technology in Africa with respect to manufacturing and agricultural technology, mining and civil engineering, transport and communication and warfare. In her study of "The Place of Indigenous Iron Technology in the Development of Awka Economy" EURICE NWOKIKE[11] documents a unique example of how the mode of pre-colonial African development was based on the growth of iron technology. The Awka people in Nigeria (as in most other communities in Africa) manufactured various products which were used in the local community or sold to other African States. The skills displayed in the smelting of iron ore surprised the Europeans when they arrived in the 1800's. They could not believe that they could meet a community with such technological knowledge and ingenuity.

The technique of iron smelting was well-known and indigenous furnances were also widely used. NWOKIKE mentions various types of furnances which were used in prehistoric Africa. These included the pit furnance, the Nupe forge, the Taruga furnance and the shaft furnance. Blacksmiths in Awka produced cutlasses, hoes, knives, guns spearheads, swords using local kilns and furnances. These iron workers were organized in guilds; and there were also brass - bronze - and gold smiths.

Everyday life situations in pre-colonial Africa also thrived on indigenous industrial technology such as the manufacturing of clothing soap, leather, food and drinks as well as industrial fuels. Weaving with the hand-loom still persists in Africa. It was this development that turned Kano City into the 'Manchester' of West Africa by the 1850s. The processing of staple foods and drinks such as peto, Ogogoro, Palm-wine etc. are still widespread.

Agricultural techniques in Africa consisted of shifting cultivation of land clearing, using the cutlass, and land tillage using the hoe, both of which were produced locally by blacksmiths with wrought iron and shaped wood. In the savannah regions, simple ox-drawn ploughs were also used.

Mining technology had also been identified in many parts of Africa in the mining of gold and rock salt.

In Civil Engineering, the construction of houses, palaces, roads and simple bridges were widespread.

Transport technology in the pre-1860 era seemed to have been restricted to camels and horses and to dug-out canoes. The canoes were usually carried out of wood and in the early 19th century, probably used sails.

Military technology consisted of the manufacturing of bows and arrows, spears, cutlasses, swords, knives and later guns, produced locally by black-smiths.

With the imposition of colonial rule, in most parts of Africa indigenous technology declined. For example the Europeans banned the manufacture of local technologies (e.g. guns) and made them illegal. The Europeans, partly by establishing a stronghold on the distribution of African products and partly by swamping African products by importing European goods eventually succeeded in putting an end to the expansion of indigenous technology (e.g. the demands of traditional societies) were gradually eroded.

Inspite of their potentials indigenous technologies have all along been neglected by most developing countries. This is because in their effort to developing countries have come to rely on the importation of Western technologies rather than adopting or moulding indigenous technologies to achieve results. This marked the beginning of the transfer of technology which has become widespread in contemporary times.

Transfer of Technology

It is widely held that since developing countries generate little indigenous science and technology (compared to advanced countries) and have remained as economic and technological colonies of advanced industrialized societies they have had few opportunities to develop their own technological strength.[12] Thus the source of new technology in developing countries has been from the advanced industrial countries through the mechanism of international technology transfer.

International technology transfer is the flow of purposeful knowledge across national boudaries "in whatever context for whatever reason to whatever country."[13] International technology transfer may occur through a variety of processes, including licenses and patents, supplies of machines and equipment, exchanges between scientific bodies of various countries, purchase of technical publications, consulting and engineering services by foreigners, on-site training of indigenous personnel by foreign experts, and students studying abroad.[14]

However the flow of technology is not distributed evently among the countries of the world. A report of the UNCTAD secretariat stated that.

> "it would take 80 years (for the developing countries) to reach the 1975 levels (of the developed countries) with an annual GDP growth of 3 percent, 60 years with an annual growth of 4 percent and 50 years with one of 5 percent".[15]

In the meantime, of course, the advanced industrialized countries would not be standing still in technological developments and improvements. There is thus an ever-increasing gap between the advanced industrial states (i.e. the

North) and the developing countries (i.a. the South). Consequently, the developing countries individually and through organizations like the United Nations, have included technology in the North-South dialogue and discussions of the new international economic order. Science and technology have become linked inextricably with trade, monetary issues and direct foreign investment and at the same time they have become critical issues in their own right.[14]

Concerns of Developing Countries

What then are the major concerns of developing countries as it pertains to the impact of science and technology?

1. Excessive dependence on developed countries

On major concern of the developing countries as it pertains to science and technology has been what they consider to be their excessive dependence on the advanced industrialized countries for their development, and what appears to be an inevitable perpetuation of that dependence. Developing countries are now entangled with advanced industrialized countries in an asymmetrical relationship due to the trade patterns that developed during the colonial period. This is most dramatically stated by Walter RODNEY when he said:

> "the basic reason (why European technology failed to make its way into Africa during the many centuries of contact between the two continents) is that the very nature of Afro-European trade was highly unfavourable to the movement of positive ideas and techniques from European ... to African system of production.
>
> (Colonialism and Slavery) did not induce in Africa a demand for technology other that firearms. The lines of economic activity attached to foreign trade were either destructive like ivory hunting and cutting camwood

> trees ... A remarkable fact that is seldom brought to light is that several African rulers in different parts of the continent saw the situation clearly, and sought European technology for internal development, which was meant to replace the trade in slaves.
> Europeans deliberately ignored those African requests..."[17]

In recent years the commodities produced in developing countries and sold in the international market largely reflected the demands and tastes of the markets of advanced industrial societies. Similarly ther consumer goods of interest to developing countries reflected the production patterns and tastes of the industrialized countries. Because the industrialized countries possessed more elaborate technical know-how, patents, finance and management techniques, the developing countries looked to the advanced countries for their supplies of capital-intensive consumer items which were too complex to manufacture in developing countries. Thus developing countries had to be dependent on advanced industrialized countries for whatever transfer of technology would be forthcoming at the latter's own inclination and pace.

2. Direction of Technology Flow

The direction of technology flow has continued to reflect the dominance of advanced industrialized countries. A report that contributed to the development of the U.S. policy for General Conference on Science and Technology for Development in Vienna in August 1979 stated that:

> "it seems clear that the extent of private technology flows to developing countries will depend on whether conditions in each country (markets, regulations, institutional and business capabilities and so forth) attract such flows"[18]

The direction of technology flow is further heightened by the establishment of the General Agreement on Tariffs and Trade (GATT) brought into being mainly by the advanced industrial countries who then supervised and controlled international trade.[19]

While this power was used by the advanced industrialized countries to direct trade flows, the fact is that trade patterns have also continued to reflect the dominance of this same advanced countries.

3. Ownership of Patents

The asymmetry of technical knowledge in favour of the advanced industrial countries is seen most vividly in the negligible ownership of patents by developing countries, compared with the developed countries. Studies by UNCTAD have revealed that only 6 percent (200,000 of the world's 3.5 million patents in existence in 1972 were held by the developing countries and that less than one-sixth of that total (30,000) were held by nationals of those countries [20]. The remaining 170,000 patents were held by foreigners, mostly multinational corporations[21] . Apparently, Western dominance of Third World patents has, if anything been increasing. In Chile for example nationals held 34 percent of all patents in 1937, but only 5 percent thirty years later.[22]

4. Appropriateness of Technology

Another concern of developing countries relates to the "appropriateness" of the technology by advanced industrial countries. Much of the technology transferred to developing countries is typically capital intensive and labour saving, whereas the chief problem in most developing countries is unemployment. The different circumstances under which such technology is developed and the unwillingness of the developed countries and the multinational corporations to adapt it to the local setting make it inappropriate for the developing countries, given their need to provide employment.[23] Thus, machinery and equipment transferred to the developing countries have been labeled "inappropriate" because they were machines of older vintage. Not only was the technology out of date, but also the developing countries or consumers in these coountries were being charged high prices for the old technology.[24] For example a well-known Textile Mill in Nigeria had the misfortune of purchasing a fifty years old piece of technologically obsolete equipment for its take-off. In deciding whether a technology is appropriate or not the following criteria suggested by ABDULLAHI[28] could be used:

1. Appropriate technology should be compatible with local, cultural and economic conditions (the human material and cultural resources of the economy)

2. The tools and processes should be under the maintenance and operational control of the population

3. Locally available resources should be fully utilized

4. If imported resources and technology are used, some control must be made available to the community

5. Appropriate technology should maximize the use of local energy resources whenever possible

6. It should minimize pollution

7. It should have little cultural disruptions

8. Research and policy should be integrated and locally operated in order to ensure the relevance of the research to the welfare of local population (the use of local raw

materials), the maximization of local creativity and the participation of local inhabitants in technological development.

Issues Arising from Transfer of Technology to Developing Countries

1. Pricing of Technology

Even where the technology transferred to the developing countries is welcomed by the developing countries, there is generally a dissatisfaction with its price. The developing countries maintain that the cost of transferred technology is unnecessarily inflated. For example, it is charged that members of the pharmaceutical industry are among the highest cost sellers of technology and dramatically overprice their products. A recent OECD report stated (on the evidence of US Senate reports) that some ingredients were over-priced by 1,000 percent rf even 5,000 percent[26]. The developing countries consider technology already developed to be part of human heritage and that all countries have a right of access to such technology to improve their standard of living. Moreover they are of the view that they have paid enough to the developed countries through the exploitation of their natural resources that facilitated the development of the advanced industrial countries at their expense. Developing countries are therefore incensed by the fact that payments for technology, in their attempt to industrialize, strain their balance-of-payments position. An UNCTAD study estimated that the Third World would pay over $10 billion for the right to use patents, licenses, process know-how, technical services and trademarks by the end of the 1970s[27]. The chief technology exporters (the United States, France and Britain) netted $5.4 billion worldwide in 1974 from payments for technology[28] and in 1980 receipts by U.S. from royalties and fees totaled yearly $5.7 billion, many times more than the amount paid in royalties and fees by U.S. firms.[29]

But how do advanced industrial countries view the transfer of technology to developing countries? The advanced industrial countries maintain that technology is proprietary knowledge, a human product based on ingenuity and capability that merits commercialization and it should be sold only at the owners (and developers) description.

The arguments by the developed countries on this issue may be summarized as follows: First, that technology is privately owned by corporations and that governments of the industrialized countries cannot mandate transfer of technology even if they wanted; secondly that technology will be transfered only if the conditions are suitable and thirdly, that technology is expensive, and it is only appropriate that developed countries demand a "fair return" for the technology transferred to developing countries.[30] These arguments differ greatly from those advanced by developing countries.

2. Tie-In Clauses in the Sale of Technology

Most technology is often sold in packages with "tie-in clauses". This compels a license to purchase unpatented goods from the licensor; in other cases technology may be supplied only through turnkey operations where the supplier undertakes full responsibility for construction of a plant and managing it until local personnel are ready to do so. Particularly where the recipient of the technology is subsidiary of the supplier, as often is the case, the recipient country acquires little, if any, "new" technical know-how.[31]

3. Paucity of R & D Resources

As part of their strategy to facilitate technological development and minimize cost of imported technology, the developing countries have been trying to get the multinational corporations operating in their jurisdiction to establish research and development centres in the local setting. They have been unsuccessful in their endeavour. One OECD-sponsored study of sixty-five subsidiaries of more than twenty-five multinational corporations in twelve countries of varying levels of development, economic structure, size and geographical locations revealed that R & D activities in centres attached to subsidiaries were practically non-existent[32] but were concentrated mostly in the parent company's home country. There are good reasons for this, including the economies of scale involved in centralizing R & D, the availability of highly trained scientific and engineering personnel, close interactions between members of the scientific community, and more effective management of the R & D function.[33] But the technology gap is widened, not narrowed by such policies.

4. Reverse Transfer of Technology ("Braindrain")

One of the results of the transfer of technology is what is known as "reverse transfer of technology" or "brain drain". Not only are the developed countries and their multinational corporations unwilling to establish R & D and other facilities that could employ and train local skilled labour, but, paradoxically, the developing countries in need of foreign assistance are an important source of highly qualified personnel for the developed countries. UNCTAD studies estimate that, for the fifteen-year period from 1960 to 1975/76, skilled migration from the developing countries (consisting of engineers, scientists, physicans and surgeons, and technical and kindred workers) to the three major developed countries - United States, Canada and the United Kingdom) amounted to over 300,000 persons[34]. Officials in the developed countries have attempted to make their immigration policies responsive to their domestic labour markets by applying more selective criteria for immigration applicants[35]. For example, in the U.S., high on the list of priorities are those people with education and skills needed in the US labour market; very low on the list are unskilled workers. Consequently, scientists, engineers, doctors, and the more highly skilled are more likely to gain permission to immigrate to the United States that are other less skilled categories; this contributes to the brain drain from those countries desperately in need of building their indigenous technogical capabilities.

Implications

Now, if we take these issues into full consideration, we are led to conclude that what is needed at this moment is not just an increase of international technology transfer nor even the setting up of a sceening mechanism permitting only appropriate technologies to be transferred; rather what is needed is a major re-orientating and restructuring of science and technology at two levels: the domestic and the international level.[36]

On the domestic level, it is important to build a popular technological awareness crossing the popular technological awareness crossing the borderline between the so-called traditional and modern technology. People should become aware of the issues in science, technology and society (STS) and that they can improve their livelihood by modifying and improving traditional and modern technologies. R & D should not be an activity left to scientists and technologists in laboratories but rather R & D should be built by making improvements on existing technology traditionally evolved in the village communities.

On the international level, the re-orientation and restructuring of science and technology must touch on three areas:

1. On the study of science and technology in schools, scientists, technologists and science educationists of different cultures, languages and social systems must build new paradigms for science and technology education from a multi-cultural perspective.

   Science and technology must be seen as existing in all cultures, the issues must be taught and the potentials of these must be explored in everyday life situations.

2. An acceptance of the restructuring of R & D systems could permit the developing and the industrialized countries to engage in a dialogue on alternative R & D, assessment of technology for development, concrete measures to redirect government R & D from technocratic to need-oriented technology development e.t.c. and joint R & D for alternative technologies.

3. The North-South and South-South dialogue will have to be closely related to the international and domestic structural change required to build a New International Economic Order. For example, the advanced industrialized countries will have to redirect their investments from technocratic bigscale R & D (e.g., military R & D) to need-oriented R & D. A scheme for decentralizing of technology systems, determining the optimal size and location of various technologies, should be negotiated domestically and internationally by both industrialized and developing countries.

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3 KEYNOTE ADDRESSES

3.3 Myriam Krasilchik:
Science-and technology education and the quality of life: The desicions a responsible citizen has to make

Brazil has approximately 130 million inhabitants, but how many of them are actually responsible citizens?

An immediate answer would be: all those who vote and who comply with their civic duties. Although this criterium may be used to characterize the citizen, it covers only a few of those elements that make up a broader concept of citizenship. Being a responsible citizen also implies in knowing one's rights and obligations, in thinking for oneself, in having a critical view of the society in which one lives and, especially, the disposition to transform reality for the better. Thus, the first important decision that a citizen must make is that of resolving to exercise his citizenship.

However, besides the personal qualities, the exercise of citizenship depends also on the space that the citizen has in which to act, actually voting and participating in the decision making process of his community. In certain countries and communities, this space is already assured. In many other cases it must still be conquered by those who really wish to take advantage of their rights and who intend to bring about the changes they consider essential to strengthen the institutions and manage to build a fair and pluralist society.

The community does not always have the opportunity to manifest itself, and it is possible to verify that in countries with several degrees of development and different political structures, the citizens must find forms of participation that involve popular movements, public manifestations and the formation of pressure groups to bear influence on the decisions that are made in realms outside of the reach of the majority of the population. Besides these, other spaces are also used, other forums of argumentation are law courts (legal reasoning); scientific communities (scientific reasoning); medical specialists (scientific, legal, and moral reasoning). (MANENSCHIJN, 1985).

Thus, reorganization of the society always implies in the development of a collective thinking in which the school comes to be also a forum of reasoning about the struggles of the contradictory forces that make up the society, involving the practice of teachers and students.

Within the curriculum, sience courses play an important part in the task of preparing citizens, as is indicated by the current movement which seeks to relate science and the society of which this meeting is an integral part. Many of the subjects necessary to youths find in the scientific disciplines a niche which is appropriate to their development:

- thinking for oneself, obeying reason instead of blindly obeying authority;
- being capable of analyzing the control processes that are used on the citizen;
- systematizing the partial, fragmented knowledge acquired in one's daily life through contact with the family, with friends, and at work, so as to understand what one is doing, why one is doing it, and how one should do it;

- understanding and accepting the complexity and multiculturality of the society in which one lives;
- understanding the different levels of decision in which one must act to solve conflicts that demand decisions which may be on any one of various levels (individual, family, communitary, national, or international),
- understanding the role of science and of the scientist within contemporary society.

To achieve these aims, it is up to science teachers to develop a series of attitudes which include, among others:

- intellectual rationality and honesty;
- the capacity to analyze problems based on observation and on one's own interpretation of facts and evidence;
- curiosity and a desire for new knowledge;
- an interest in study and recognition of the limitations of one's own knowledge;
- recognition of the possibilities and limitations of science and of technology;
- the capacity and disposition to take action in the attempt to solve problems.

Thus, the already overloaded science teacher has to make decisions when dealing with societal issues which include:

The issues

The science teacher must be able to bring to the surface everyday themes that are of interest to the students - themes that are derived from their concrete problems - and relate them to more general situations that will lead to a broad and profound analysis of dynamic and complex processes which demand knowledge in many areas.

The problem of the pollution of a river or of a certain region is intimately related to production problems in the region under consideration, and therefore, to economic problems. Discussions held in developed and underdeveloped countries as to the use of nuclear power involve aspects such as technological progress, potential dangers, and the use of alternative sources of energy.

Issues such as populational growth, the use of urban and rural space resources, the use of medicines, sanitation, agriculture, all involve decisions that depend on a sound basis of information and knowledge, as well as judgments as to their desirable or undesirable effects, which depend on the code of values of the community and on the life quality that the community desires.

The role of science and technology in contemporary society is worthy of special attention on the part of the science teacher. Both suppositions of fearful respect which alienate a great many citizens, and the adoption of a suspicious attitude which attributes most of humanity's problems to the scientists, must be avoided.

Access to information on science as a social activity, in language which is accessible to the majority of the population, must begin in the schools which have, among other obligations, that of developing the capacity to analyze information and values transmitted by the media and which may represent interests of certain groups instead of representing the interests of the community in its broadest sense. Frequently science is used as an argument in debates on political, philosophical, and religious ideas. Many controversial themes have a scientific dimension which is invoked to justify clearly ideologic positions. The rights of the scientist and of the citizen when it comes to options about what sort of research should be carried out, and what should be done with the results of the research, are also issues that must be faced in class.

Ethical teaching dilemas

Teachers have to handle extremely complex situations in their dealings with students who do not yet have sufficient knowledge, experience, and maturity. An essentially ethical problem arises from this situation: how is it possible to discuss values with students without indoctrinating them? Is it possible for the teacher, whose relationship with the students is a matter of hierarchy, to remain neutral when faced with a problem which involves the adoption of an ethical and moral standard? To my way of thinking, no teacher can claim total neutrality since his opinion is already manifest in his choice of matters to be dealt with in class, as well as in the way he deals with these matters.

To quote MONOD (1974), "Values cannot possibly be derived from any sort of objective knowledge. But if you think about it a bit more, you find that, in fact, objective knowledge cannot exist, cannot begin to exist, unless there is an active choice of values to begin with."

Only by creating situations of conflict, by exposing the interests involved without using his authority to impose opinions, can the teacher help to form citizens capable of deciding for themselves what sort of actions to embark upon in their search for the general welfare and to achieve the changes they consider necessary. A crucial part of the process is the development of the capacity of argumentation involving sincerity and capability in the desire to convince and to listen to others who may have arguments that could cause us to change our minds.

Although any proposition as to linear procedure may be simplistic, some steps are an integral part of the process of decision making as related to societal issues:

- one must identify moral, ethical issues, which implies, basically, in distinguishing between facts and values;
- one must develop procedures for analyzing societal issues. This step involves consideration of the information that will be necessary in making a decision, and of the principles that must guide solution of the conflicts;
- one must choose one alternative from among the many that are available, and put it into practice.

To educate for freedom without restricting the school to the role of forming malleable, manageable citizens is the great challenge which faces todays science educators. And in this case, the voice of caution tells me that this challenge will be met, not by giving in to the temptation of grandiloquent slogans, but by sticking to the reality of the classroom, with all its possibilities and limitations, the transformation of which is one of our fundamental objectives.

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3 KEYNOTE ADDRESSES

3.4 Bryan Chapman:
Science and technology education and the quality of life: The impact on future careers

I have been invited in this plenary session to consider the implications of technological change for employment. In my submitted paper I drew attention to employment predictions for the United Kingdom which extend beyond the symbolic Year 2000. These predictions showed two things very clearly; first, overall demand for labour is set to decline and second, and this is particularly challenging for participants in this conference, it is science and technology based labour that is most at risk as a result of these changes. This paradox, that increasing deployment of advanced technology reduces rather than increases the importance of science and technology education in the curriculum is, as yet, little appreciated by those concerned with making educational policy decisions. Certainly not those who also naively assume compulsion leads to commitment. Perhaps we had better make hay while the sun shines!

Inevitably the experience I have drawn on in preparing this paper is based on experience gained in the U.K. However, in this age of multinational conglomerates no country stands alone and it would be quite impossible to explore this issue in a purely national context. Arguably this has always been the case. All empires that have ever existed have depended on exploitation for their economic prosperity. Today's commercial empires are transnational in character owing allegiance not to countries but to shareholders whose interest in that company very rarely extends beyond its balance sheet. The daily stockmarket report now rivals the weather forecast and sports results for the prime slot in daily news bulletins.

This does not stop governments deluding themselves that they still control their own destiny. In the U.K. we are now experiencing a push towards a centralized curriculum in which the sciences and technology will be expected to play a dominant role. Why we need a scientific and technologically competent workforce for an economy in which employment in manufacturing industry is in terminal decline is not clear. The implication of this state of affairs is that politicians still have not grasped the nature of the technological change that is transforming the global economy. What we will actually need in the U.K. is geriatric nurses, as, of course, will all the developed nations of the world through to the next century. This does not mean that we do not have technological 'skill shortages' in our work force; we do. But higher pay to technologists may be the answer to this, not compulsory technology in the curriculum. Of course, if every young person becomes technologically competent, they become a source of cheap technological labour. We live in a world in which the law of supply and demand reigns supreme.

If colleagues detect a certain amount of cynicism in what I am saying they will not be mistaken. Even in those countries which are traditionally lauded by the U.K. government as being better able to train technicians and technologists than we are, careers in 'financial services' are increasingly take the 'creme de la creme' of their young people., When the steam engine was invented those who made the engine made the money. Tomorrow when the fifth generation computer emerges, it will be investors, totally ignorant of what the term 'parallel-processing' means, that reap most of the benefit. Nations may need young people to go into technology; whether it pays young people to be partriotic is another matter.

It would be absurd to extrapolate this to the point at which no young people were taking up careers in science and technology. However those who do will find national ties an increasing irrelevance to personal advancement. Rich countries and multinational companies will, by and large, gain the loyalty of the most able. So, what's new? The able always did emigrate. Paradoxically the more effective a national programme of technological education turns out to be the more likely are its best products to be sought elsewhere. (For elsewhere read the U.S.A.).

One further cautionary point needs to be made. Much has been said about technology 'serving human needs'. Splendid as the sentiment behind this statement is, it does beg the question as to whose 'human needs' are being 'served'. The link between technological advance and military expenditure - over half of the UK's research and development budget is devoted to military projects - is nothing new. After all Archimedes owed his position at the court of the King of Syracuse not because he unmasked a fraudulent goldsmith but because he designed weapons capable of sinking enemy warships. Even without the military dimension, how many technologists are doing something 'worth while', and how many are engaged in activities of mind-boggling triviality? Do we really need striped toothpaste? And if we do, do we need it to come out of a pump? Clearly both these technological advances served real human needs - the needs of one set of shareholders to gain a bigger proportion of the toothpaste market that the shareholders of rival companies. Some time ago a news item appeared announcing 'a revolutionary technical breakthrough giving Britain access to a market worth millions of pounds a year'. Only two plants of its kind exist in the world today. It 'extrudes and bakes a countinuous tube of crunchy biscuit to be filled with a chocolate flavoured centre at the same time'. It is a plant for producing dog food.

The catalogue is endless. Why do razor blades get blunt so quickly? Why don't privately owned Energy Corporations show the same interest in energy saving as their customers? Why were digital compact discs marketed before digital tape systems? Why do the shares of drug companies rocket every time there is a rumour that a cure for AIDS is imminent? Why have shares in rubber companies soared? Who can doubt that if 1/10th or 1/100th or 1/1... 0th of the effort that has gone into achieving the 'human needs' of soldiers and shareholders, often coincidentally, had instead gone into meeting the 'human needs' of those who recently faced totally predictable starvation in the drought stricken areas of Africa, the world would be a better place than it is today.

The reality is of course that we actually have the technology to solve most of the problems facing the world today. What we lack are the economic, social and political frameworks in which those solutions can be implemented. (Perhaps it is in this subversive direction that science and technology education should be moving?) Nothing demonstrates this better than the food mountains which are, at one and the same time, a technological achievement and an economic disaster. So, what's new? They occured in the 1930s and preceded the rise of fascism. Nor are they confined to developed nations. In some parts of S.E. Asia farmers are reported to be burning rice and chickens because of over production - on deafforested land! In developed countries we now pay farmers not to produce. (We do not, incidentally, offer miners who produce surplus coal the same deal). In Information Technology the engine driving us toward ever more sophisticated computing power is competition, both financial and military; if, on the other hand, that engine were cooperation, there can be little doubt that yesterday's 8-bit technology, incorporated into TV receivers at virtually no cost would suffice. Should the future prosperity of a company really depend on how fast it can transfer its funds across the Stock Exchanges of the world in order to maximize its profits not from production but from gambling on, or engineering, fluctuations in the world's currencies?

So, what's new? Is the situation we face today really very much different to that previous generations faced? My historian colleagues tell me that it is not. What is perhaps new is the pace and extent of the changes being wrought by Information Technology combined with their global dimension. The implications for employment are mindbending. Imagine yourself as managing director of a large multinational company devoted. Your task is to maximize the profits which accrue to anonymous faceless shareholders, amongst whom may well be your pension fund manager. Where will you site your headquarters? Where will you process your orders, undertake research and engage in manufacture? In which country will you register your company and pay your Corporation Tax? The answer will be - must be - wherever profit can be maximized in a stable political environment. (Some profit may of course have to be invested in ensuring that stability! You will concentrate your research and development in the developed world both because that is where you will be able to recruit the scientists and technologists you need and because of existing academic networks. By contrast, thanks to electronic mail and fax, much routine office work is increasingly exportable, particularly if you own your own satellite, to any country with a surplus of educated, English-speaking young women willing to type for a pittance (If they object to a pittance then fewer of them sitting at word processors working for marginally larger pittances is the likely result). If you wish to set up a new manufacturing plant then the inducements offered by free ports and special investment areas - tax incentives, low wages, lax or nonexistent legislation on workers' rights, a large pool of cheap, usually female labour - will prove irresistable. For, no matter what personal reservations you may have, you know your competitors are being offered the same. And, finally, there is no shortage of off shore tax havens in which your shareholders' would be delighted to have their dividents paid. The logic is ruthless. The name of the game is, after all, **MONEY**. And it is a game which we are all forced to play in the world as it is today.

"So what's new?" Every empire, since the beginning of time has depended for its success on running a 'heat pump' economy. The many without have always laboured for the few that have. As the Bible puts it: - "To him that hath shall be given: from him that hath not shall be taken away even that which he has". In the UK we are currently following this edict assiduously. Between 1969 and today the richest 30% of the population have increased their share of the nation's income from 52.8% to 60.0%; the share going to the poorest 30% has declined from 13% to 8.8% over the same period, a massively obscene one third loss of purchasing power from an already inadequate base line. And that is just income not accumulated wealth. On a world wide scale however this appears positively egalitarian. On every indicator available to us rich nations are getting richer as poor ones sink further and further into debt. This does not of course mean that everyone in rich nations is necessarily getting richer or that everyone in poor nations is getting poorer. What we have is a matrix of wealth distribution which is both increasingly unacceptable and inherently unstable. Globally we have now reached the stage when the amount of aid being received by the Third World is insufficient by a factor of three to pay back existing debts let alone support development. For how long can this situation continue to exist: how many banks and financial institutions are today wearing the Emperor's new clothes and praying that no one actually realizes that if not yet 'in the altogether', they are down to their financial underpants!

Many of us, when microprocessors first came in, believed - naively as it turns out - that the Information Technology revolution being ushered in would put power in the hands of the people. What we are in fact witnessing is the accumulation of power by the few. "Making a Business of Information" is the title of a 1983 UK Cabinet Office Report. It concludes:

> "... both private and public sectors in the UK need to pay much more attention to information as a commercial commodity, to be concerned with the creation and maintenance of its value .... technological changes are bringing together hitherto disparate activities - for example, publishing, film and video, and the creation of computer software - to create a powerful new economic sector, the tradeable information sector."

There can be little doubt that Rupert MURDOCH and his like are doing just this. How healthy this state of affairs is for democracy must be a matter of some doubt. Many already only know what Rupert MURDOCH through his control of the press and cable and satellite TV wants them to know. This is being accompanied by a global homogenization of cultures increasingly based on marketing rather than merit. One has only to taste Coca Cola or a Big Mac to know this to be the case.

All of the above must seem profoundly depressing to those of us who have spent a lifetime in education deluding ourselves that people should have access to information as a human right. (Laws of copyright, of course, excepted!) Historically the three things the slave, the serf, and the citizen have had to sell have been their labour, their lives and their bodies. When production and commerce no longer require that labour, when wars are fought at keyboards rather than with cannon fodder and when AIDS is causing the bottom to drop out of the body selling market what is left? Essentially that is the question which this paper sets out to address.

Information Technology and Employment.

It is clear that, in the absence of profound changes in global economics, it will be competition, both military and commercial, not cooperation, which fuels developments in IT. That being so, except at the very highest levels, industrial deskilling will proceed apace. Almost always the application of IT is going to result in higher quality products incorporating, if required, far greater planned diversity than was previously achievable. Along with this goes the much more efficient use of plant and a reduction in the need for skilled labour. Unskilled labour will however be retained providing it costs less than the interest payments on the capital investment that would be required to replace it. Recently I took a party of teachers around an automated paint factory. Every part of the process is automated except stacking the final product on pallets. 70 skilled jobs had been eliminated. But women are still employed to do this because they work for less than it costs to automate. The firm is not a multinational. It has a concern for the community in which it is based. But it had no choice if it wanted to survive. Indeed it is probable that the most effective brake on the introduction of automation is the worldwide availability of cheap labour. As the cost of automation falls even this advantage will be denied the labourer.

The impact of IT developments on employment in the Third World seems likely to be catastrophic. Just as technological advances in textile manufacaturing made it impossible for even the cheapest Hindu labour to compete, either in quality or quantity, with the output of Lancashire's cotton mills in the 1830s, so in the 1990s and beyond, labour costs will become less and less significant in all commercial, production and manufacturing operations. At a stroke this destroys one of the major reasons multinational companies have had for siting their operations in Third World countries.

In 1982 the Institute of Contemporary Arts held a series of seminars on The Social and Political Implications of Information Technology. One of these was specifically devoted to Third World issues. Papers by Dr. Juan RADA, Rita CRUISE O'BRIAN and Alan BENJAMIN have been published in "Microchips with Everything" (Comedia 1982). The journal "New Internationalist" has also considered the global impact of IT. Although BENJAMIN presents an optimistic case, particularly in relation to the utilization of IT in education and training, the other contributors are deeply pessimistic about the impact IT will have without a fundamental change in the existing economic system.

In the developed world the situation vis-a-vis employment is not very different. What we do have, however, are some cushions which delay and/or soften the impact. First we can dispense with the services of underpaid migrant workers and send them back whence they came. Then we can bring industries back from developing countries because the cost of labour has become far less significant in IT based industries. Put another way, the developed world can, and will, export unemployment. At the same time it has, despite the alarm often expressed about this, a declining word force. Whatever transient problems this creates they are as nothing compared to those which will have to be faced by countries having to cope with population explosions as the IT hurricane sweeps round the world.

In those areas of human activity in which IT can be applied it seems inevitable that IT systems will takeover both because they do the job better and because they extend what can be done. But it is not just manufacturing and clerical jobs that are at risk. Medical diagnosis; legal procedures; tax enforcement; social security assessments; point of sale credit transfer; electronic mail, education and training and many other professional activities may be more effectively carried out by 'intellectual robots' than by people. The increasing interest in 'open learning' systems puts delegates to this conference in the front line of such developments. On education and training the Cabinet Office report referred to earlier concludes:

> 'We suggest that educational establishments will come under increasing pressure from the (IT) developments we have discussed in this report. We make no firm predictions but note that educational institutions generally will need to make effective use of new technologies in order to maintain their position against competing sources of tuition and information.'

I have no doubt at all that we would all like not to believe this. Education is 'different'. Is it? The Open University which makes only limited use of most recent advances in IT has demonstrated what can be achieved and its methods are increasingly being taken up elsewhere. Clearly this has great potential for developing nations at all levels. But why just developing nations? Why have 1000 teachers teaching Newton's Laws year after year with varying degrees of competence, if a video-based system would do it better?

At the very highest level our most able scientists and technologists will, of course, find no shortage of demand for their talents. In the IT field, the Strategic Defence Initiative, the Janapese Fifth Generation programme and all the other programmes this 'panic-buttoned' into existence are all intellectual hothouses capable of recruiting the very best people. But how many? The internationalization of the entertainment industry led quite logically to a reduction in the number of entertainers required to satisfy the world wide demand for entertainment; the internationalization - rationalization - of research and development inside multinational corporations and within such organizations as the EEC seems to imply, in the medium to long term, a creaming off of the best talent rather than an overall expansion in demand for that talent. After all the logic of successful research into artificial intelligence is research conducted by artificial intelligences - on a chip!

Below the level of innovation it is difficult to envisage a significant requirement to understand technology and we grossly deceive our young people if, in including IT within the curriculum, we give them this impression. Even maintenance engineers will have little need to understand the technology they are servicing. It will fault find itself and instruct the engineer accordingly. Perhaps the main requirement for operators of computer controlled manufacturing systems will be to find ways of avoiding boredom. Of course the world is not yet completely like this, but if the logic of the technology takes us in this direction...?

The consensus view is that there will be few employment opportunities in IT and that the more sophisticated the technology becomes the less there will be. In industries which make use of the new technologies the prospects are similar. Outside this, low paid, low skilled employment will continue to exist and indeed flourish. Free-trade zones, sub contracting, union suppression, home working, institutionalized unemployment are no longer just features of Third World economies. Casual and part time work now accounts for about a third of employment in the UK and in the USA it is estimated that the number of 'peripheral' workers, inevitably low paid, has doubled since 1980 and now accounts for 17% (17 M) of the work force. Privatization in the UK has been accompanied by massive wage reductions for the employees involved. Not surprisingly, active trade unionists find their reemployment prospects in these new firms poor. IT developments, by reducing labour requirements and by decentralization of production further weaken the position of organized labour today. The rich, needless to say, benefit.

So what's new? There is an old proverb which points out that "If work were such a good thing, the rich would have found a way of keeping it to themselves long ago". Benjamin DISRAELI recognized in his novel 'Sybil' that Queen Victoria reigned over "... two nations. The Rich and the Poor". Today thanks in part to Rupert MURDOCH's control of 'information', the UK has a government committed to re-establishing Victorian values. I do not believe we are alone in experiencing this phenomenon. It is perhaps worth pointing out that had the Aids virus evolved in the nineteenth century it would have spread far faster in Victorian brothels than in what is left of the progressive society of the 1960's today.

The way we handle the employment consequences of the Information Technology Revolution is one of the major challenges facing society today. On the one hand we face the prospect of unparalleled freedom from toil; on the other, subjugation of the many by those who control the way the new technologies are deployed. Both Maynard KEYNES and Lord STOCKTON recognized the opportunities the technology creates and the danger society faces if it fails to come to terms with the social implications of that technology.

In the absence of profound changes in global economics, it will continue to be competition not cooperation which will fuel developments in IT. Competition, it is claimed, will ultimately benefit everybody even its own casualities. The question is: "When?" It has, after all, had a rather good run for its money.

It seems to me that, implicit in the setting up of IOSTE is the notion of cooperation rather than competition, of conservation rather than consumption. Yet how can we cooperate when our governments are hell bent on competing and how can we conserve when we know that it is consumption that generates the jobs that are so desperately needed by so many? Chemist's shops sell slimming aids, but they also sell Fererro Rocher chocolates, often on adjacent counters. There is a perverted employment logic in this state of affairs but we really ought to be able to organize these things better. Perhaps what we need is a heat engine economy rather that a heat pump one.

It is all too easy to be impossibly Utopian about what is required. Yet ultimately education is about ideals. Tom LEHRER once pointed out that the United States army not only bans discrimination on grounds of race and sex but also bans it on grounds of ability. And why not? Ability is just as much the result of evolutionary chance as is race or sex. If we agree, as I am sure we must, that a major objective of a civilized global society is to minimize the disadvantages that individuals suffer simply because they happen to have been born on one part of the globe that another then logically, the disadvantages of accidentally having been born with limited ability should also be minimized. This seems to me to only be achievable if responsibilities are put before rights. This should not be too difficult. Instead of defining a scale of wealth going from $0 to $(infinity) we might explore the possibility of redefining a wealth scale which has a finite maximum. Anyone contributing to the maximum of her/his ability would automatically receive that maximum. The only exception would be the handicapped and disabled who would receive more. The able already have the enormous privilege of being able. What other privilege do they - we - need?

Implicit in this is the decoupling of work from its traditional role as a mechanism for distributing wealth. Will Lord STOCKTON's prediction that "in ten to fifteen years time we shall never use the word 'unemployment'" be proved correct? If it is, then education has to play an urgent and revolutionary role in achieving this. It has to prepare young people for the use of leisure, secure in the knowledge that that leisure is a right to be given not a reward to be earned. There is little point in teaching a young person a leisure skill if it costs more than a week's dole money to pursue it. Providing people with something to do whilst the machines are doing the work may be the single most important task of government in the next century.

So, what's new? In the time of Claudius some 150 days of the Roman calendar were holidays not for religious or celebratory reasons but to disguise underemployment.

> "In the city there were 150,000 complete idlers supported by the generosity of public assistance, and perhaps an equal number of workers who from one year's end to the next had not occupation after the hour of noon and yet were deprived of the right to devote their spare time to politics. The shows occupied the time of these people, provided a safety valve for their passions, distorted their instincts, and diverted their activity. A people that yawns is ripe for revolt. The Caesars saw to it that the Roman plebs suffered from neighter hunger nor ennui. The spectacles were the great anodyne for their subjects' unemployment, and the sure instrument of their own absolutism. ...By these means the empire preserved its existence, guaranteed the good order of an over-populated capital and kept the peace among more than a million men."
>
> Daily Life in Ancient Rome. J. CARCOPINO.

So what's new? Dallas, TV Sport, SKY satellite television add up to much the same thing.

Yet all of this still gives primacy to work. We conceive of work as necessary to our existence as eating, drinking and copulating. The real revolution would be to remove this feeling of necessity. The poet Philip LARKIN wrote of 'the old toad, work'. Life should be better, he mused, without 'the old toad'. Yet in the end he concludes:

No, give me my in-tray,
My loaf-haired secretary,
My shall-I-keep-the-call-in-Sir,
What else can I answer,

When the lights come on at four,
At the end of another year?
Give me your arm, old toad;
Help me down Cemetry Road.

D.H. LAWRENCE, never the most practical of romantics, put work very much in its place:

> There is no point in work unless it absorbs you. Like a absorbing game, if it doesn't absorb you, then its never any fun. DON'T DO IT!

Information Technology doesn't, as yet, allow most of us to go this far. It has however provided us with slaves. The Greeks also had slaves. They needed to find things to do to occupy their time. I doubt whether they invented the concept of leisure; what they did have was a word for it. That word was 'skhola'.

Perhaps the single most important, and therefore subversive, role for science and technology education as we move into the Information Technology Society of the future is to make young people aware of what that society is likely to be like. In doing that it may be that our economics, history and sociology colleagues have at least as important a role to play as we do in achieving that awareness. Whether we will be allowed to do this is, of course, another matter entirely.

SO WHAT'S NEW?

Postscript

A UN body was recently reported as having suggested that Tourism would soon become the most important industry worldwide. Perhaps that's new. Except that the Phillipines with a Ministry of Education, Culture and Sport may have got there first.

4 WORKSHOPS AND POSTERSESSIONS

4.1 A. Bargellini, L. Lardicci, N. Longo, G. Raspi, P. Riani: Chemistry, technology and history

Introduction

In view of the proposed reform of the Italian upper secondary school and of the extension of compulsory schooling to the age of 16 (present limit 14), our research group on chemistry teaching is planning to develop a series of didactic units for the teaching of integrated sciences in the first two years of the upper secondary school (14-16 years). The most important characteristic of these didactic units lies in their "Motivational importance", each unit being based on a subject fundamentally connected with natural resources, history, economics, technology and industry of the Tuscany Region.

On this occation we illustrate the first of these units, which has as its underlying theme the study of an Etruscan environment. Everything here presented is part of an experimental activity which has involved teachers and students of a Scientific High School in Pisa.

Prerequisites for the chemistry aspect

CONCEPTS: element, compound, chemical, reaction, oxidation and reduction, energy

PROCEDURES: to observe, classify, separate variables, hypotetize, deduce

ABILITIES: to manipulate, experiment, use simple chemical equipment, collect samples

LANGUAGE: to be able to communicate using basic chemical terms

Learning cycle and content

1) Motivational Phase

Students started with the analysis of historical documents, on the basis of which they discussed and broadened their knowledge of the most important aspects of the Etruscan civilization.

2) Exploration Phase

With the help of the maps provided in the above mentioned documents, students were able to recognize some environments in Tuscany, rich in mixed sulphureus minerals (pyrite and chalcopyrite) and other iron minerals, such as haematite and limonite, exploited since Etruscan times. In these environments, even today, one can find some well preserved Etruscan furnaces as well as deposits of scoria from mineral workings dating back to that time. The students subsequently explored the chosen environment, gathering various types of materials: minerals, samples of scoria, living organisms.

3) Development phase

After the classification of the materials gathered, the students worked in pairs in the laboratory, carring out chemical analysis of minerals and scoria, noting in particular the presence of iron, copper and sulphide ions.

4) Reinforcement phase

Numerous examples of oxido - reduction reactions were observed; the limitations of the metal working technology of the past were also noted.

5) Synthesis phase

This phase represented the conclusion of the whole activity; it was also the most complex one. The problems faced related to the process of interaction between man and environment relative to the exploitation of environmental resources by the Etruscans and that carried out today.

The questions which acted as starting point for a more indepth examination of various problems were the following:

- What were the environmental consequences of mineral smelting with wood?
- How is the present day technology different from that used by the Etruscans?
- What is the difference between copper and iron metallurgy?
- What importance did this difference have in the past?
- What are the basic differences between the prototype of an Etruscan furnace and a modern blast furnace for iron metallurgy?

We can outline the following main integration areas:

I Environmental chemistry and technology. The smelting of minerals with wood gave rise to the destruction of all trees in the region.

II Chemistry and technology. Copper technology is easier than iron one. The product of a primitive iron furnace is either non carburated (too tender) or carburated (hard, but very brittle). Etruscan people did not know steel technology.

III Chemistry, technology, history and economics. The primitive iron technology produced scoriae with a great iron content. Scince 1900 up to 1960 the exploitation of Etruscan scoriae was considered profitable.

6) Evaluation

On conclusion of the activity the students presented a written report and answered written and oral questions with regard to the initial objectives.

References

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4 WORKSHOPS AND POSTERSESSIONS

4.2 A. Bargellini, L. Lardicci, M. Mannelli, G. Raspi, P. Riani: Observations on some chemical parameters in a fresh-water system using autonomous low-cost material

Introduction

The Pisa University group researching didactics in chemistry planned and experimented a series of activities of an experimental nature for Italian middle schools (11-14 age-group) (1). On this occasion a poster is to be presented illustrating one of these activities which involves the examination of several chemical parameters of a fresh-water environment (located near the mouth of the River Arno) with the UNESCO aim in environmental education (2): "to design and evaluate new methods, materials and programmes (both in school and out of school, youth and adults) in environmental education".
The activity was experimented with a group of middle school teachers using autonomous low-cost material.

Pre-requisites

a) Conceptual area concerned: Acid and bases, chemical reaction, organism, environment, eco-system, interaction.
b) Scientific Procedure: to observe, measure, be able to recognize cause-effect relationships.
c) Ability: to manipulate, be able to use simple equipment.

Didaktic strategy: R. GAGNE's cycle of didactic strategy from facts to principles to "problem-solving" was preferred to J. BRUNER's inverse strategy (3).

General Aims

a) To consider the examination of chemical parameters in a fresh-water environment as indispensible starting point for the study of organism-environment relationship.

b) To define a didactic strategy aimed at stimulating the pupils' interest for environment problems.

c) To consider the exploration of a fresh-water environment from a chemical point of view as starting-point for the development of an integrated sciences didacatic unit.

d) To acquire an awareness of the importance of environmental protection for the continued existence of living organisms.

Specific Objectives

a) To acquire the following concepts: homogeneous and heterogeneous system, sampling, reagent, reaction, precipitate.

b) To acquire the following scientific procedures: observe, measure.

c) To acquire a capacity to manipulate simple equipment (thermometer, test tubes, funnel) and to carry out simple operations of a chemical nature (obtain water samples, filter and carry out simple chemical reactions).

Learning Cycle and Content

a) Exploration Phase. A fresh-water environment particularly suitable for reaching the established aims and objectives is chosen (presence of aquatic life).

b) Development Phase. A sample of the water is taken and by means of a series of materials and reagents contained in a special container the water is analysed, noting above-all the presence of oxygen, chlorides, sulphates, and the temperature and pH of the water are measures.

c) Synthesis Phase. On the basis of the results obtained the following problems are faced and discussed:
   - drinkability of the water
   - desalinization of the water
   - pollution of the water
   - the use of fertilizers

d) Evaluation. On conclusion of the activity the results obtained are tested by means of written questionnaires containing open and multiple-choice questions.

References

Bargellini, A., Lardicci, L., Mannelli, M., Raspi, G.: "Children's conceptions in the acquisition of some chemical concepts at middle school level", Widening the Scope of chemistry, Takenki Y., editor - Blackwell Scientific Publications, 1987.

Dyasi, H.M.: International cooperation in environmental education - Environmental education key issues of the future, Proceedings of the Conference held at the College of Technology, Farnborough, England - Hughes Evans D., Editor - Pergamon Press, Oxford, 1977.

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4 WORKSHOPS AND POSTERSESSIONS

4.3 H. Bayrhuber, H. Hebenstreit, E. Lucius, U. Nellen, P. Nevers, R. Westphal: Biotechnology

Introduction

The impact of new developments in biotechnology has led us to establish a working group at our Institute which deals with questions concerning the treatment of biotechnology in schools. We saw a need in this area since the teachers in our country have had little experience in teaching this topic as our syllabuses do not include in depth treatment of biotechnology.

We feel that performing experiments in classes is of particular importance. However, our schools are normally not sufficiently equipped for biotechnological experimentation. Moreover, our teachers are not trained well enough in this practical field. Most of them have not studied microbiology at all. Therefore we are developing materials for practical work in schools, especially low cost materials. We also intend to use this equipment for in-service training courses for teachers as well as in courses for university students.

The workshop was designed to acqaint participants with some results of our practical work. Low cost materials were demonstrated and their functions were explained.

In addition to adequate equipment teachers require practice in basic microbiological techniques. In cooperation with the UNESCO we are compiling a set of such techniques for the use in the classroom. Our concept of basic microbiological techniques was elaborated during the workshop.

One of the major problems of practical biotechnology in schools is the safety of experimenting with microorganisms. The risk of students and teachers becoming infected can be reduced by using harmless microbes, especially strains which are employed in the production of food like cheese, yoghurt or sauerkraut. The participants were introduced to our work with lactic acid bacteria and with different stages in the production of cheese that can be performed in the classroom.

Another field of the application of modern biotechnological methods in the area of agriculture is plant breeding. We showed the participants an example of a practical approach to this field demonstrating how to cultivate plant tissues on agar under sterile conditions. An adequate understanding of the use of modern biotechnological methods in agriculture requires consideration of non-biological aspects as well, especially economical questions. In this context we demonstrated a cost calculation in which conventional and modern cultivating methods of an important ornamental plant, GERBERA, are compared.

Low cost materials

Commercial laboratory equipment is usually designed for science research and therefore very high standards are set for these appliances. Schools do not require such sophisticated experimental equipment. It is more important that pupils understand how an apparatus works. Therefore we developed some instruments guided by the following idea:

An instrument for teaching purposes must be easy to reproduce, and all of them have to be reasonably priced. The basic construction and design provide insights on the function of the apparatus.

During the workshop the following equipment was demonstrated:

- An incubator which is appropriate for cultivating medium plates or liquid cultures at temperatures between 29 and 42 degrees Celsius (Cost: DM 40,--). The box of the incubator is made of styrofoam. At the bottom of the box is a 15-Watt electric bulb. It continually produces heat, which is dispersed by air circulation. The temperature in the inside of the box rises until an equilibrium between gain and loss of heat is reached. It is possible to regulate the loss of heat.

- A shaker which is capable of agitating liquid cultures in laboratory flasks at room temperature (Cost: DM 35,--). It prevents a mouldy membrane from being formed on the surface of the culture medium, which in turn allows an exchange of oxygen. Shaking is necessary for all aerobic microorganism cultures. The main idea of the shaker is a four wheeled carriage which is driven on by a windshield wiper motor.

- A magnetic stirrer which is used for preparing microbiological experiments, for instance for mixing solutions, for pH-measurements etc.
  It facilitates experimental procedures and helps to save time (Cost: DM 15,--).

- A selfmade photometer which is suitable for determining the optical density of colored or turbid solutions.
  Among other things it can be used to examine the effect of enzymes with the help of indicators, to measure the concentration of various ions in drinking water or to follow the growth of a bacterial culture.
  A growth curve of a bacterial culture derived by photometric measurements was shown.

Basic microbiological techniques

Materials for practical work in schools were prepared in form of autodidactical units directed to the secondary school biology teacher. They emphasize both knowledge and skills.
The materials represent a selection of techniques already described in extensive literature about microbiological experimentation. They describe in detail a series of procedures and experiments which are suited for use in the classroom, for example methods of sterilization, maintenance of equipment, cultivation of bacteria, performing a dilution series, preparation of broth cultures and stock cultures an slant agar, measuring the increase in cell number, determining the titer of a culture, heat fixation and staining.
The participants in the workshop performed a dilution series by simple means with droppers such as one obtains with certain kinds of medicine.

Work with lactic acid bacteria

Cheesemaking is a classical biotechnological process that has advanced to the status of modern biotechnology in the course of industrialization. This topic is well suited for an exemplary demonstration of the scientific basis of biotechnology as well as the social, ecological and economic implications of biotechnology on an industrial scale. In order to acquaint participants with various aspects of cheesemaking they were first introduced to a simple procedure for making homemade cheese and invited to sample the results. Problems concerning pasteurization and whey disposal and the high costs of natural aging were discussed. Then a series of experiments were presented demonstrating the use of dairy microorganisms in cheesemaking and the economical problems arising from the detrimental effects of bacteriophage contamination during the fermentation process. In the discussion that ensued, additional aspects of cheesemaking on an industrial scale were considered such as the lower cost of the product, possible negative effects on the quality of the product and changes in occupational demands as a result of changes in technology.

Plant breeding

The aim of a teaching unit on the influence and the importance of biotechnology for modern agriculture is to make the students aware of the change which has already taken place in industrial agriculture. New biotechnological methods, especially plant cell and tissue culture in vitro (which means under sterile conditions in petri dishes on artificial media) have been introduced in plant propagation and plant breeding. A vast field of possible applications of genetic engineering in plant breeding still lies in the future.

A variety of agricultural, horticultural and forestry products which we buy or use today result from plants cultivated in vitro. Examples are virus free seed potatoes or barley cultivars, the parent generations of hybrid maize, sugar beets, vegetables such as aspargus or paprika, fuit trees and ornamental plants. The students are encouraged to recognize their own part as consumers in the interplay of economy, profit and ecology and form their own opinions.

Another goal is to encourage students to think about the transformation which biotechnology will evoke in the organization of agriculture or various occupations and to consider the influence it may have on ecology and economy. The following examples of experimental plant cultures in petri dishes were demonstrated.

The first series showed the initation and growth of a sterile tobacco culture. Seedlings and larger plants were grown on nutrient agar without roots and produced multiple shoots due to the presence of a plant hormone which stimulates cell division. The generation of plantlets from isolated leaves or pieces of leaves was also demonstrated. In some cases the undifferentiated callus tissue arose from which complete plants were regenerated. In some cases the plants formed roots on medium containing auxin and were ready to be replanted in pots.

The second series showed the importance of the composition of the media. The main components of plant media are sugar as a carbon source, a mixture of salts containing all the elements necessary for plant growth, vitamines, plant hormones to stimulate differentiation, agar and water. Six day old mustard plantlets were cultivated on media which lack one or more components. Only the plantlets on complete medium grew well.

The third series demonstrated how to establish a callus culture from small sterilized segments of carrots. Cells cultivated in light develop chloroplasts. A close look at the callus cells with a dissecting microscope revealed different rates of cell division as well as root formation in the medium containing auxin. We wish to give students an impression of the biological and physiological background of the methods used in plant tissue culture by means of experiments. In addition, the students should also receive information about the utilization of these techniques in agriculture and about their economic potential. For this purpose we have chosen the following plants for closer examination: the important crop plants potato, maize and barley and the ornamental plant Gerbera.

During the workshop this topic stimulated a lively discussion about the possibilities of teaching practical biotechnology in school.

4 WORKSHOPS AND POSTERSESSIONS

4.4 Robert Bowen: Technology for primary schools

Background

The HMI document "The Curriculum from 5 to 16" (1985) identifies nine areas of learning and experience in which all schools should involve pupils:

> aesthetic and creative, human and social, linguistic and literary, mathematical, moral, physical, scientific, spiritual and technological.

It is suggested in the document that these are not discrete elements to be taught separately from one another and that they do not equate with particular school subjects. They do say, however, that it is essential that:

> each of the above areas of learning and experience is represented sufficiently for it to makes its unique contribution.

Primary schools should ensure that children have access to an education that encompasses this unique contribution. By engaging in technology children experience the intellectual processes of generating, manipulating, adapting ideas and the physical processes of using materials when developing practical solutions to problems which are rooted in the man made world but often have social and environmental considerations.

Structure

The workshop focussed on the contribution that technology can make to young children's education. The session started off with a slideshow which illustrated the range of work undertaken in this area and demonstrated links with other curriculum areas.

The group was introduced to the nature of technology as applied in primary classrooms by participation in a practical activity. The activity was "grounded" in the context of children's literature, the problem being to:

> "make an interesting 'moving face' which might be used as part of a literature based Topic".

Groups of participants had to prepare a statement that described an 'interesting face', stimulation being provided by means of extracts from current children's literature, then translate the statement into a model that incorporated some form of movement.

Outcomes

The practical activity produced a number of interesting interpretations of brief, ranging from simple movements using springs to more complex mechanisms using levers. The evaluation of these provided stimulation for broader questions regarding this area of the curriculum. As part of the evaluation the group addressed a number of critical questions:

> "What is technology contributing to children's learning in mathematics, language, science, etc...?
>
> Which technological skills and concepts are intrinsically worthwhile for primary children?
>
> What does technology offer that does not otherwise occur in children's school experience?
>
> How can technological learning be evaluated and recorded?
>
> What resources are essential and what are useful?"

I was not intended to provide definitive answers to these questions during the session, they were intended as reflective, to be addressed in depth at a later date. They did provide, however, a focus for discussion the outcome of which was positive in that participants felt that technology could make a valid and contribution to the education of children in the primary phase.

Reference

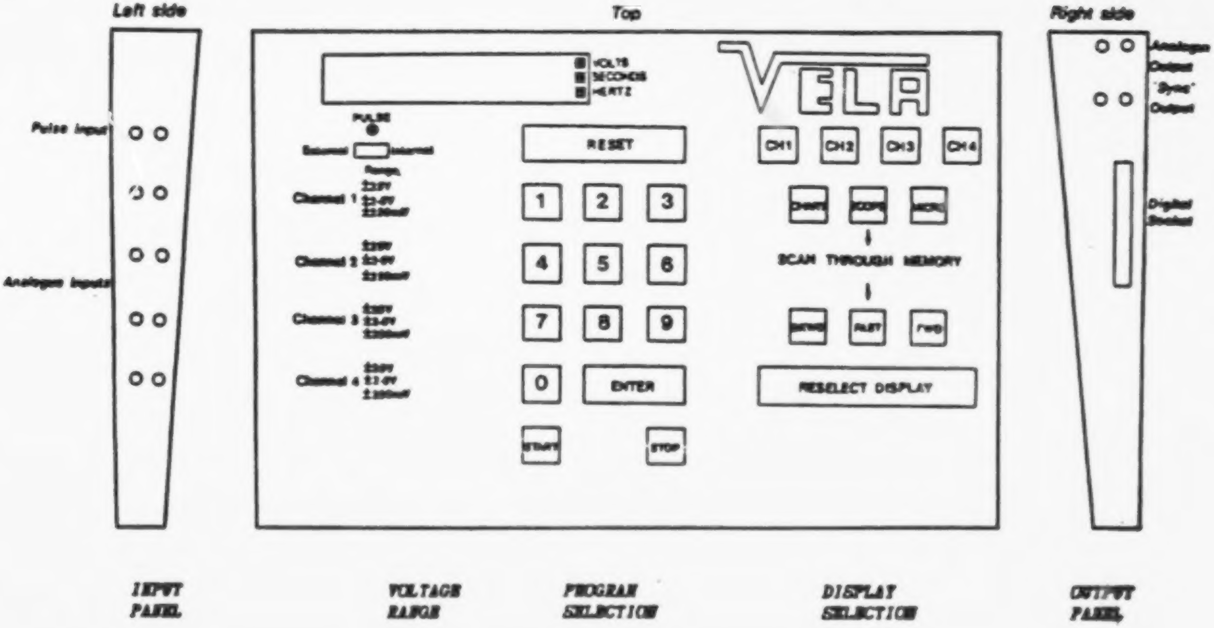
HMI: The Curriculum from 5-16: Curriculum Matters, 2 HMI Series, HMSO 1985.

4 WORKSHOPS AND POSTERSESSIONS

4.5 Bryan Chapman:
The VELA approach to school science laboratory instrumentation

VELA is the name that has been given to a **VE**rsatile **LA**boratory Instrument developed by Dr. Ashley CLARKE and Dr. Keith JONES of the University of Leeds Department of Physics in conjunction with a group of local Physics teachers. Originally designed as a low cost microprocessor based system for use in school science, it has found many applications at undergraduate level, in research and in industry. Because of its low cost, mechanical and electrical robustness, versatility, ease of use and independence from computers, it would seem to have great potential as a means of introducing modern instrumentation techniques into the science and technology curriculums of developing countries at university if not school level.

VELA incorporates all the essential elements to be found in modern instrumentation systems. Input voltages from up to four sensors can be simultaneously processed and stored by **VELA**. This means that any physical entity - temperature, pressure, PH, humidity, wind speed, oxygen content, light level, radio-activity - can be monitored by **VELA** using standard transducing devices. Each of the four channels will store 1,023 separate readings. The interval between readings is determined by simple key-pad entries and ranges from 34 micro-seconds up to 999 seconds. Once an experiment has been completed, stored data can be output, still using simple key


Left side
Top
Right side
Pulse input
Analogue inputs
VOLTS
SECONDS
HERTZ
PULSE
External
Internal
Range
Channel 1
Channel 2
Channel 3
Channel 4
RESET
1
2
3
4
5
6
7
8
9
0
ENTER
START
STOP
VELA
CH1
CH2
CH3
CH4
SCAN THROUGH MEMORY
FAST
FWD
RESELECT DISPLAY
Analogue Output
'Sync' Output
Digital Socket
INPUT PANEL
VOLTAGE RANGE
PROGRAM SELECTION
DISPLAY SELECTION
OUTPUT PANEL

VELA KEYBOARD AND INPUT/OUTPUT FACILITIES.

presses, to either a CRO, a chart recorder, a printer or any micro for which there is suitable software (e.g. Apple, IBM and BBC micros).

In its original form VELA was supplied with 16 built in programs. By keying in 00 on its digital pad it becomes a 4-channel digital voltmeter; 04 turns it into a frequency meter; 05 an event timer; 09 a ratemeter; 10 a wave form generator and so on. The original list of programs has now been extended to 80, all simply called up by keying in a two digit number. For example 63 converts VELA into an energy meter, 64 a power meter, 71 a capacitance meter and 72 a phase meter. Programs 66 - 69 give direct measures of velocity and acceleration, and programs 70 and 73 allow four separate temperatures to be monitored and datalogged. In the past instrumentation limited what could be done in science education. Today that is no longer the case. With the advent of microprocessor based measuring instruments, the limits are now provided by our, and our students, imaginations. VELA offers a low cost and simple to use way into this new field.

Some of these uses of VELA were demonstrated at the workshop. Programs 16 and 36 are designed to allow users to create their own routines and this extends VELA's potential to the research level. However these programs also form the basis of an introductory Control Technology course for 14 - 16 year old students. Some simple Lego Buggy control programs were demonstrated during the workshop. A pupil workbook accompanies this course.

Further details of VELA can be obtained from the manufacturer (Educational Electronics, 28 Lake Street, Leighton Buzzard, Bedfordshire, LU7 8RX.) and/or Dr. Ashley CLARKE (Instrumentation Software Limited, 7 Gledhow Wood Avenue, Leeds LS8 1NY.).

4 WORKSHOPS AND POSTERSESSIONS

4.6 Peter Edwards: Control technology

Project Technology was a major curriculum development of the late 1960s early '70s to promote a better understanding by boys and girls in school, of the importance and relevance of technology. The project was concerned with helping teachers to stimulate an awareness of the material and scientific forces which effect change in our society, in the UK, and to develop knowledge of these forces and their means of control by the direct involvement of pupils in technological activity.

This project concerned itself with a teaching material writing programme. Writing, followed by trials and editing the material was undertaken using the flair, imagination and experience of teachers, who, for many years had been developing work of a technological nature in areas of the school curriculum.

These produced materials together with the Control Technology course identified the diverse nature of work being done in schools at this time, and of the alternative teaching methods and organization which are possible.

The Control Technology course followed the setting of clearly defined educational objectives. Appropriate teaching methods, based on pupil assignments, with supportive texts and equipment were progressively developed with the support of the Project Technology team.

The developed Control Technology course is intended to last for three years, on the basis of 5% curriculum time for 13 years olds and 10% curriculum time for 14 - 16 year olds.

A series of carefully programmed investigations and experiments, using purpose-designed equipment should take approximately half the total time allocation. The remainder of the time is used for projects of varying lengths. These projects, initially being linked to the programmed sequence of units. This enables pupils to gain experience in demonstrating interpretations of unit knowledge and skill in the environment of constrained project work. Many pupils, at this stage, need confidence in being responsible for their problem solving/decision making techniques demanded in such project work. Building pupils ability to respond autonomously and with greater independence is an essential feature as a major project of six months or more duration demands considerable preparation.

The manner of the course elements and their associated methods,

1) programmed or sequential assignments and follow-up sheets
2) teacher demonstrations
3) homework questions and assignments
4) project work

whilst aimed specifically at stimulating the natural inventiveness and enthusiasm of pupils, is also sympathetic to the teaching force. Without considerable in-service-training of the teachers the initiation of any course would falter. The attempt, with Control Technology, is to provide complete support for teachers who have limited specialist knowledge through the provision of

1) a teachers handbook - containing information on aims, objectives, methods and teaching suggestions, together with special knowledge, text and costings on appropriate materials for the teaching of the course.

2) Pupil Assignments Book - a programmed, sequential series of experiments and assignments (most of which have more than one possible solution) which, under guidance from a 'manager', provide a framework for pupil learning by doing and recording.

3) Pupil Follow-up Notes - a series of notes giving possible solutions and explanations in the sequence of pupil assignments.

The syllabus covers areas such as

Structures	- analysis and synthesis of structural form and principle
Rotary motion	- mechanical systems and associated principles
Linear motion	- mechanical, electrical and pneumatic systems

Basic electricity	- simple principles in application
Switching-electrical	- means of simple control using basic electrical components, simple feedback
Swiching-pneumatic	- methods and applications
Logic circuitry and applications	- more complex systems in electronics, pneumatics and electrics including closed-loop feedback

Within the workshop, which was undertaken in one of the nine mobile laboratories used in the UK as a means of taking specialist facilities and trainers to areas of the country where the in-service training of teachers takes place, opportunity was given for participants to experience, as pupils, the nature of the programmed sequential assignments within the field of electrical switching.

This concerned the examination by guided experimentation simple switches by which a small battery-driven-wheeled model vehicle could be controlled forward and in reverse, manually and automatically (sometimes with a time delay).

The discussion which followed concerned the effectiveness of the teaching materials as methods of learning. It has been found that the course provided pupils with motivating materials which enabled pupils to have insight into how control systems, in aspects of our industrial life, worked, as well as giving the confidence and competence to tackle the solving of problems such as:

a) Warning devices
b) Dispensing devices
c) Sorting devices
d) Display devices etc etc

The breadth of the course, which includes questions, is limited, but deliberately so. However, this does not mean that the course methods and structure lack flexibility. It was always intended that the course should reflect the fact that technology is essentially a dynamic process. The latest techniques and developments which are relevant to work at school level can be incorporated by the enterprising teacher, especially by way of minor and major projects.

As to the ability level of intended pupil participants, average and above-average ability pupils were and are the suggested target for the course. However, an interesting and stimulating course can also be provided for the less gifted by adapting the content (normally by choosing careful omissions, thus allowing more time to be spent on the remaining). It is time to say, however, that teachers often underestimate the capacities of pupils 'to demonstrate by doing' through projects.

4 WORKSHOPS AND POSTERSESSIONS

4.7 Günter Eulefeld:
Water pollution

Set up and content of the workshop

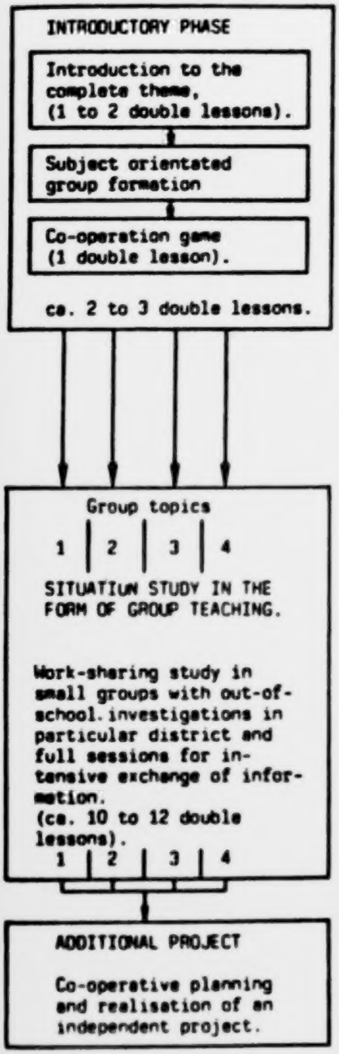
The workshop aimed at the demonstration and discussion of an IPN instruction unit on PROBLEMS OF WATER POLLUTION for students in grades 9/10 (age 14 to 16) as a model for environmental education with the Tibilisi (UNESCO) characteristics:

- interdisciplinarity
- problem-, situation-, action-orientation
- small, independently working group of students

It is proposed in this unit to deal with the problem without separating it into scientific or social science aspects in the relevant subjects (biology, geography, social studies). Thus the pupil is given the opportunity to recognize and work on the problems of water pollution in their entire complexity.

This instruction unit was tested with about 1000 students in more than 30 classes in all types of secondary schools in Northern Germany under normal schooling conditions.

Course plan and time allocation (teacher's manual)


INTRODUCTORY PHASE
Introduction to the complete theme, (1 to 2 double lessons).
Subject orientated group formation
Co-operation game (1 double lesson).
ca. 2 to 3 double lessons.
Group topics
1
2
3
4
SITUATION STUDY IN THE FORM OF GROUP TEACHING.
Work-sharing study in small groups with out-of-school investigations in particular district and full sessions for intensive exchange of information.
(ca. 10 to 12 double lessons).
1
2
3
4
ADDITIONAL PROJECT
Co-operative planning and realisation of an independent project.

The INTRODUCTION PHASE gives the students an idea of the problem to be investigated (film: Polluted Water) and of the preferred method: gathering information in the community. Information on the prepared four topics is given and the small groups are set up by choice. The students play a game which provides them with relevant experience to formulate rules for their own co-operation behaviour

GROUP TOPICS

A: **The investigation of water**

(1) Biological indicators for the investigation of running water pollution in our locality

(2) Oxygen analysis for the investigation of running water pollution in our locality

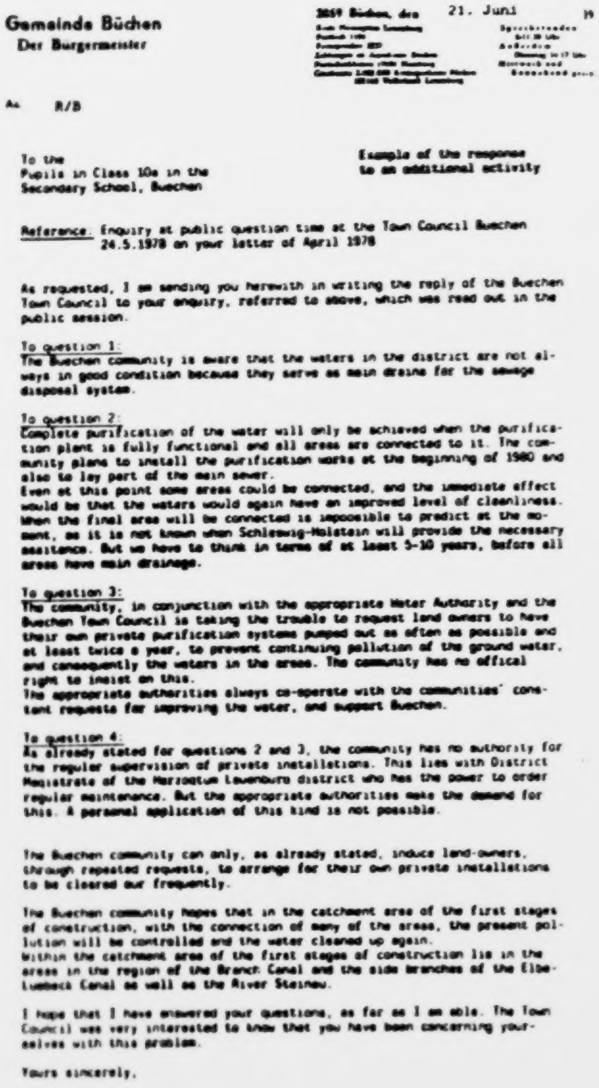
B: **The waste water problem**

(3) What does our community do to keep the water clean;

(4) Investigators and those affected Or: How do people see the water situation in our locality.

During the SITUATION STUDY the students learn to investigate and form opinions on water pollution in their own locality. This is one of the prerequisites for learning ecologically sensible actions in relation to the subject. Besides work sharing and problem study in specialist groups an integrated knowledge should be obtained through systematic information exchange and the preparation of a complete report by the whole class on the local water situation.

An important objective is that the pupils should be able to carry out their own "additional project". The development of this ability is important especially in the context of environmental education. This competence - which may be named ecologically sensible - depends on the development of relevant knowledge in relevant situations and of the ability to communicate in a responsible and problem-solving manner. (see figure 2)



Gemeinde Büchen
Der Bürgermeister

2059 Büchen, den 21. Juni 19

Az. R/B

To the
Pupils in Class 10a in the
Secondary School, Buechen

Example of the response
to an additional activity

Reference: Enquiry at public question time at the Town Council Buechen 24.5.1978 on your letter of April 1978

As requested, I am sending you herewith in writing the reply of the Buechen Town Council to your enquiry, referred to above, which was read out in the public session.

To question 1:
The Buechen community is aware that the waters in the district are not always in good condition because they serve as main drains for the sewage disposal system.

To question 2:
Complete purification of the water will only be achieved when the purification plant is fully functional and all areas are connected to it. The community plans to install the purification works at the beginning of 1980 and also to lay part of the main sewer.
Even at this point some areas could be connected, and the immediate effect would be that the waters would again have an improved level of cleanliness. When the final area will be connected is impossible to predict at the moment, as it is not known when Schleswig-Holstein will provide the necessary assistance. But we have to think in terms of at least 5-10 years, before all areas have main drainage.

To question 3:
The community, in conjunction with the appropriate Water Authority and the Buechen Town Council is taking the trouble to request land owners to have their own private purification systems pumped out as often as possible and at least twice a year, to prevent continuing pollution of the ground water, and consequently the waters in the areas. The community has no offical right to insist on this.
The appropriate authorities always co-operate with the communities' constant requests for improving the water, and support Buechen.

To question 4:
As already stated for questions 2 and 3, the community has no authority for the regular supervision of private installations. This lies with District Magistrate of the Herzogtum Lauenburg district who has the power to order regular maintenance. But the appropriate authorities make the demand for this. A personal application of this kind is not possible.

The Buechen community can only, as already stated, induce land-owners, through repeated requests, to arrange for their own private installations to be cleared our frequently.

The Buechen community hopes that in the catchment area of the first stages of construction, with the connection of many of the areas, the present pollution will be controlled and the water cleaned up again.
Within the catchment area of the first stages of construction lie in the areas in the region of the Branch Canal and the side branches of the Elbe-Luebeck Canal as well as the River Steinau.

I hope that I have answered your questions, as far as I am able. The Town Council was very interested to know that you have been concerning yourselves with this problem.

Yours sincerely,

Figure 2: Example of a result of an activity carried out by a class in their local community

Discussion

Three main questions were the central topics of discussion.

1. How to help students to have their own experience on environmental problems?

This question can be answered by focussing the activities to their own locality and to an important environmental problem with which each community is confronted. The students are not only to learn facts supported by the teacher, but are also to learn how to act in their own district and community in order to find out how people handle their own environment and how they face the problems. So the students have Step 1 as a first task (see figure 3).

2. How to help students to get enough information and to have enough freedom in order to work independently and with good motivation in small groups for several weeks ?

Four group guidance programs have been developed for the four topics. In each we guided the students step by step through the whole learning process. In STEPS we formulated ideas how to proceed in the work, in TEXTS we gave necessary information, in CONTROL STEPS we formulated questions for the records and KEY CONCEPTS to be explained in the plenary sessions (see figure 4).

3. How to help students to cooperate in an optimal way in small groups?

By means of a cooperation game students gain experience about the influence of individual behaviour on the results of group work. They discuss this and then formulate rules for their own group work (see figure 5).
Some rules for group work, which were formulated during tests of the co-operation game, are quoted on page 134 (figure 6).

STEP 1

Opinions about Water Pollution in Our District

(1) The first step is the same for all groups. Consider the following questions in your group first of all, and then in the whole class (in "full session").

Which of these statements do you agree with in your group?

a) In our district there is polluted water/polluted water in some areas.

b) In our district the water/the water in some areas is in good condition, it is not polluted!

if a) 1. Which areas?
  2. Why are these particular places especially polluted?
  3. Who is responsible for this? All of us? Only certain people? Which ones? No-one in particular? Perhaps some more than others? What are the connections? etc.
  4. Who suffers most from water pollution? Who, therefore, is most severely affected?

if b) 1. On what do you base your assertion that the water in your area is . in good condition?
  2. How could you "prove" it?
  3. As there are problems in every district over keeping the water clean, it is important for us, and for every member of the community to find out how the problem has been overcome in this district.
  4. Who is responsible for water purification in your community? Which installations are particularly important for purifying the water successfully in your district? Which groups bear most of the cost for this purification? What problems are there?

If you are not able to answer these questions, then pay particular attention to point 3). Then consider these questions again!

(2) Please record the assertions to which the class agreed in the full session. Assertions about certain places in the running water in the area could be really clearly demonstrated e.g.in the form of a sketch of the whole water situation in your district. You could fill in the details of this sketch during the course of your work. An example is shown on the next page.

(3) Plan a combined survey of these places with the whole class. Then you can consider with your teacher which places would be suitable for investigation. It is important for each one of you to make his/her own sketch of the running water in the district, otherwise it is not really possible for you to make a useful contribution to a discussion. Pay particular attention in the survey to sewage outlets. Indicate these points on your sketch.

Figure 3

STEP 10

Domestic and Industrial Water Pollution

The biochemical oxygen demand is an important quantity for comparison when estimating water pollution. It can be used for example to compare domestic with industrial waste. In this the so-called "individual comparative value" plays an important part. Please read about it in Text 10.

CONTROL STEP TO STEP 10

Question for your records:

- What is meant by individual equivalent value?

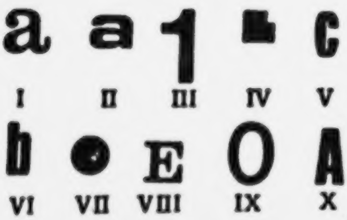
FOR THE FULL SESSION

Key Concepts

- individual equivalent value
- organic pollution

Figure 4

The co-operation game consists of a classification problem, which the pupils should solve, in two stages, first of all individually, and finally in small game groups[16].



The accompanying illustration shows 10 figures I to X. None of the figures has the same surface area as the others. In the correct order they differ from one another by about 5%.
The problem of the game consists in discovering the correct sequence of the figures illustrated by estimation.
Only the filled in areas of the figures counts.

The problem is constructed in such a way that the sequences made by the pupils vary according to experience. In tests carried out so far, the players have employed the following solution techniques:

- Count the size of the figures on millitmetre-squared graph paper or squared paper;
- Divide the rows of figures into three groups, the larger, the middle-sized and the smaller and then arrange these within their groups;
- Reconstruct the figures in the same figure type (e.g. rectangular) (if necessary by cutting into pieces);
- Lay the figures on top of one another.
- Calculate the area of the figures (using an approximate method).

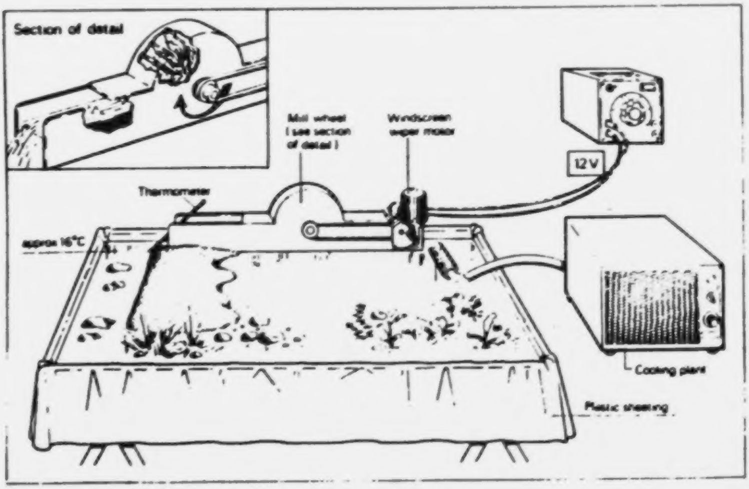
Figure 5

- "Everyone should be allowed to express an opinion, everyone should be listened to".
- "All work together".
- "The majority is not always right".
- "No independent actions".
- "Be patient".
- "No-one should have too much influence".
- "Discuss and agree".

Figure 6: Examples of group work rules

4. Modell of running water

During the workshop a model of running water was shown which may easily be built in any school.


Section of detail
Mill wheel (see section of detail)
Windscreen wiper motor
12V
Thermometer
approx 16°C
Cooling plant
Plastic sheeting

References

G. EULEFELD et al.: Probleme der Wasserverschmutzung. IPN-Einheitenbank Biologie. Köln: Aulis Verlag, 1979.
The English version is published under the titel: Problems of water pollution. (Kiel: IPN, 1987) and may be obtained from the author.

4 WORKSHOPS AND POSTERSESSIONS

4.8 Ard Hartsuijker: Integration of elements of computer and information literacy in science education

Introduction

In the Netherlands a national project on Computer and Information Literacy for lower secondary education is run by the National Institute For Curriculum Development (SLO). In national policy there is an emphasis towards the integration of parts of this new subject into the curricula of other schoolsubjects, among which Science Education. In the workshop an outline was given of the process of curriculum development and the products developed till now.

The Computer and Information Literacy Curriculum

1 General goal

Education in Computer and Information Literacy should enable students to react intelligently to situations in which the use of data processing systems is possible or necessary. Moreover, it should enable students to use data processing systems, and judge critically the social significance of the use of such systems.

2 Sub goals

a) The education should enable students to gain insight into the applications, the possibilities and the limitations of automatic data processing systems.

b) Moreover the education should enable students to process data and extract the desired information from a selected amount of data.

c) The education aims that students can operate data processing systems and can use them on the principle of a functional model.

d) The education should make students aware of the significance of information technology for the individual and for society, and enable them to express an opinion on this.

3 Elements of education

Elements of education are divided into four categories derived from the four distinguished sub goals. The categories are:

A Applications of information technology
b Information and data processing
C Data processing systems
D Social significance of information technology.

In category A (applications of information technology) elements are enumerated giving students insight in the kind of applications, possiblities and limitations suitable for their level, e.g.:

- data bases
- word processing
- administration and business applications
- simulations
- process control.

Category B (information and data processing) centers on elements related to data and information, and how information can be obtained, processed and made available by students. Without knowledge of category C (data processing systems) and without operational skills based on the principle of a functional model of such systems students can't hold

themselves in information society. For the reason a number of elements has been formulated.
The elements of category D (social significance of information technology) concern on the awareness of the significance of information technology for the individual and for society and on the capability to express an opinion on that.
The classification into the categories A through D has never been meant as the didactical sequence for teaching. The SLO suggested to center education in Computer and Information Literacy around applications of information technology (category A) with subsequent attention to the other three categories.

Elements of Computer and Information Literacy relating to Science Education

In consultation with teachers and teacher trainers we made a survey of goals and elements of Computer and Information Literacy that can be elatorated in Science contexts, and on goals and elements of Science Education having a supporting role in Computer and Information Literacy.

1 Elements relating to Science Education

In the Computer and Information Literacy curriculum there are several elements of education which can relate to Science Education. These are:

- Students are able to work with computer simulations.

- Students have knowledge of the purpose of computer simulations, such as: predicting the behaviour of a system, education and training, they know various stages in the development of a simulation model (among which comparing the model with reality), and they are informed about the pros and contras of computer simulations.

- Students can solve practicle problems on data collection and process control, using components as sensors and actuators.

- Students are acquainted with basic functions of data processing systems, such as: measuring, counting, calculating, reading, writing, storing, visualizing, representing, ordening, selecting, sorting, combining.

- Students have knowledge of advantages of data processing systems, such as: speed, repetition, accuracy, storage of a large amount of data, efficiency, verifiability, and of disadvantages, such as: loss of flexibility, and they realize that only certain aspects of reality can be quantified and can be processed by data processing systems.

- Students have knowledge of the changes being brought by all kind of applications in information technology in various sectors in society.

- Students have knowledge of the influence of information technology on (the kind, the amount, and the quality of) labour, communication between people, privacy and environment.

2 Elements relating to Computer and Information Literacy

Elaboration of elements of Science Education having a supporting role for education in Computer and Information Literacy produces the following possibilities:

- Development of practical skills, e.g.:
  - data collecting, data processing and data analysing of time dependent variables in an experiment;
  - coupling of sensors and actuators to an interface, reading sensors and activating actuators.

- Development of problem solving skills, e.g.:
  - developing a conceptual model of a physical or biological process;
  - realising a computer simulation model in an appropriate simulation language or LOGO environment.

- Exemples of using computer applications in science themes or contexts, e.g.:
  - using data bases for identification of biological species;
  - using computer simulations for investigation of physical or biological processes.

- Consideration of themes relating to science, e.g.:
  - principles and operation of data processing systems;
  - principles and operation of interfaces, sensors and actuators:
  - principles and operation of telecommunication;

    of course the emphases should be here on the functional model and not on the physics.

3 Bests possibilities for integration

This consultation of a group of experts in the educational field, c.q. teachers and teacher trainers, revealed a striking correspondence on three elements of Computer and Information Literacy:

- Using simulations
- collecting and analysing data
- using data bases (especially within biology).

It was also noticed that with regard to problem solving and practical skills there is a large similarity in procedures in Science Education and Computer and Information Literacy.

4 An integration example

As an illustration of the integration of parts of Computer and Information Literacy into the curriculum of Science Education the SLO developes teaching materials and a computer simulation program on an ecological system, that can be used in both subjects. Students can approach the simulation in several ways: they can see the simulation as an example of an application of Information Technology, experience it and reflect on the use of computer applications in society, but they can also use the simulation as a problemsolving tool and build themselves a conceptual model of real world by comparing the outcomes of the simulation when changing and extending the biological model.

4 WORKSHOPS AND POSTERSESSIONS

4.9 J. Kortland, H. de Jager:
Dilemma's in environmental education (within science teaching)

Set-up and content of the workshop

In the Netherlands environmental education is a much debated issue. In general the debate focusses on the aims and contents of environmental education and on the way(s) to integrate environmental education into the different existing school subjects (as it is impossible - and probably undesirable - to make environmental education a new, separate school subject).

We - the organizers of this workshop - are in the middle of the debate, being staff members of the curriculum development project **Environmental Education in Secondary Schools** (Dutch abbr.: NME-VO). A project which has as its main task to develop research based teaching materials and curriculum proposals for environmental education within the science-subjects and geography at the secondary level[1]. Our job is to find ways out of a number of six interconnected dilemmas's facing environmental education[2].

During the workshop three of these dilemma's were introduced briefly by the workshop organizers and subsequently discussed by the workshop participants, with the aim of finding ways out of these dilemma's.

Three dilemma's facing environmental education within sience teaching

The three dilemma's discussed during the session can be summarized as follows:

- should environmental education be aiming at education for the environment or at education about the environment;
- should environmental education adopt an issues based or a discipline based approach;
- should environmental education deal with specific contents or with the structure of contents.

These dilemma's are related respectively to the why, how and what of environmental education.

Discussion

1 The aims of environmental education

Most workshop participants did not see the dilemma as really being a dilemma: environmental education should be aimed at all six interconnected dimensions, regarding knowledge, skills and insight as a necessary but not sufficient basis for (a change in) attitudes, values and behaviour. The real dilemma might be the assumption that knowledge, skills and insight will automatically lead towards (the development of) desired attitudes, values and behaviour. 'Normal sience' doesn't differ from environmental education in the sense that the hidden message is the same: we want students to integrate their acquired knowledge and skills into their personal life. The difference between ' normal science' and environmental education is that within the latter the message isn't kept a secret: 'the difference in environmental education is that we are not ashamed to show our objectives on attitudes and behaviour'.

2 An issues based or a discipline based approach

The answer to the question of an issues based of a discipline based approach might depend on the ability level and age of the students. However, a generally accepted view was that environmental education should be issues based, certainly in the earlier years of secondary education, with a preference for local issues to start with (motivational factor).

The dilemma didn't raise much discussion among the workshop participants. Then why did we call it a dilemma? The answer to this question might be that this dilemma only emerges when trying to integrate environmental education into the existing science subjects: then the conflict between the demands of environmental education (issues first, uncertainties about 'right' solutions to problems etc.) and the generally perceived nature of science as a discipline (a fine structure of related concepts and laws, clear cut answers to (textbook) problems etc.) becomes appearant. Could it be possible that this dilemma of an issues based versus a discipline based approach didn't raise much discussion because in most cases environmental education (or environmental science) - and STS-education more in general - is taught as a separate course alongside or instead of the main-stream science courses in secondary education? Pointing in that direction are remarks like: 'The basis of environmental education is 'issues', disciplines take care of themselves'.
The problem with integrating environmental education into the science subjects is: finding an acceptable balance between an issues based and a discipline based approach[3].

3 The contents of environmental education

The existence of a general structure of environmental issues, suitable for analysing specific issues was doubted. It appeared to be easier to identify a number of 'elements' of environmental education at a general level:

- knowledge of the (tentative) character of scientific knowledge: metaknowledge about science;
- knowledge of an ability to assess and evaluate risks, learning to accept and deal with uncertainties, different viewpoints of experts, and the existence of more then one solution for science related social issues;
- knowledge of a limited number of key-concepts like probability, (ir)reversability of processes, (eco)system etc.;
- mental skills like being able to analyse, synthesize and evaluate.

Next to the issue of how to incorporate these elements adequately in teaching materials and teaching methods, remains the problem of teacher response towards most of the elements identified. These have not been, and still are not dealt with in teacher education. Dealing with uncertainties, be it in science itself or in science related social issues, is new and threatening for most science teachers and science teachers to be. So should there be more emphasis on incoporating environmental education - or STS more in general - in pre-service science teacher education?
There seems to be a consensus on the point that which environmental issues are selected for dealing with in the classroom is of secondary importance. A list of desired 'elements' of environmental education at a general level can be put together rather quickly. May be the trouble starts when trying to make these general statements more specific, like: what then are all the key concepts, and why are they key concepts. Or when we try to translate these general statements into teaching materials and classroom activities. And that is not only a question of design, it is also a question of research and evaluation: how do we know to what extent students have reached the educational objectives

(which are not always as clear cut as they appear to be - and here we have returned to the first dilemma). It is our impression that research in this area is still sporadic.

Notes

1 An outline of the project's ideas on the character of environmental education within the science subjects and geography and of the research programme connected to the development and evaluation of the teaching materials can be found in:

   * Kortland, J.: **Environmental education from the perspective of broadening the aims of science education.** In: Riquarts, K. (ed.): Science and Technology Education and the Quality of Life, Kiel (FRG) 1987, vol 2 pp. 546-555.

   * Jager, H. de: **Students' beliefs concerning environmental issues** - paper presented at the 4th International Symposium on World Trends in Science and Technology Education, Kiel (FRG), 1987.

2 The six dilemma's were originally formulated by K.Th. Boersma (head of the science department at the Dutch National Institute for Curriculum Development SLO) in a keynote lecture during the first large conference which brought together Dutch teachers, teacher-educators and curriculum developers with an interest in environmental education.

3 Practical experiences on finding a balance between an issues based and a discipline based approach (when dealing with the integration of STS and academic physics courses at the secondary level) are described in:

   * Eijkelhof, H.M.C. and Kortland, J.: **Broadening the aims of physics education - experiences in the PLON project.** In: Fensham, P.J. (ed.): Development and dilemma's in science education, Falmer Press (to be published in 1988).

4 WORKSHOPS AND POSTERSESSIONS

4.10 Charles McFadden: ASCP: An approach to junior secondary science teaching

1. If the approach to teaching science in the early years of school is phenomenological and in the final years, systematic, what should be the approach in the intermediate years (ages 12 - 15)? Over the past ten years the Atlantic Science Curriculum Project has developed and tested materials to support an approach to teaching science intended to develop (1) an understanding of selected scientific concepts preliminary to their more systematic study in the final years of school, (2) scientific, communication and learning skills needed for life-long, adult learning and (3) attitudes which support the continued study of science as a relevant and essential activity for all in the present age. The workshop is designed to illustrate and invite comment on the following features of ASCP Science: (1) the use of language and language tasks in teaching science, (2) the use of the graphic potential of a textbook, (3) a holistic approach which integrates science for action and science for citizenship with the development of basic scientific understanding and skills and (4) a student assessment strategy consonant with the goals of the program.

2. The workshop, attended by approximately thirty educators, began with an examination of materials developed by the Atlantic Science Curriculum Project for the junior secondary level. Attention was focussed on the teaching strategies provided for by the materials, including provision for arousal of interest, reconstruction of meaning, consolidation of understanding through language activity, STS context, career guidance, and student assessment consonant with a wide range of objectives.

   Interest was expressed by many of the participants in international collaboration in curriculum development within the context of IOSTE and its future symposia.

3. ASCP Science is being published under the title, SCIENCEPLUS, by Harcourt Brace JOVANOVICH, accompanied by Teacher's Resource Books. SP1 and TRB1 were published in 1986; SP2 and TRB2 were published in 1987 and SP3 and TRB3 are in press.

4 WORKSHOPS AND POSTERSESSIONS

4.11 H. Mikelskis, R. Götz: Renewable energy resources

Renewable Energy Resources

In the future of the world's energy supply renewable energy resources will play a more and more important role. Solar and wind energy projects in Schleswig-Holstein were presented by videos, slides and written materials during the workshop. There was no doubt, that this topic should be part of every school-curriculum. Table I gives an overview of the possibilities how to integrate this new theme into the school subjects. But every teacher should be aware that teaching about "Renewable Energy" has to be more than only a new topic of Applied Physics, Chemistry or Technology. It should be interpreted an arranged as part of Environmental Education, which has to be understood as an integrated interdisciplinary principle and as a task for all school subjects. It can be described along the following aspect:

- learning because something concerns me,
- understanding our situation as historically developed,
- developing the senses and training perspective faculties,
- phenomenological and holistic learning,
- developing powers of judgement,
- learning to act,
- orientating toward a imaginative creation of future.

Between others during the workshop three school materials were presented:

Subject Topic	A Mathematics	B Physics	C Chemistry	D Biology	E Geography/ Geology	F Technology	G Politics/ Economy
1 Solar Collectors/ passive Systems	Calculation of Efficiency	Radiation Theory, Heat Transport, Efficiency	Selective Layers	Greenhouses	Solar Radiation, Weather conditions	Solar Energy System, Architecture	Research and Development, Cost and Benefit
2 Solar Cells/ Photovoltaic	Calculation of Efficiency	Photoeffect, Electricity	Electrochemical Processes, Photoeffect		Solar Radiation, Weather Conditions, Production	Solar Toys/ Cars/Watches, Technical Measurement	Energy Use, Laws for Housing
3 Windenergy	Efficiency, Theory of Windpower	Generator, Aerodynamics, Efficiency, Magnus Effect	Material Problems		Wind, Weather	Wind Energy System	Industrial Production
4 Bioenergy/ Biogas			Fermentation, Alcohol, Methane, Hydrolysis	Biomass, Photosynthetic Process, Bacteria, Digestion	Animal Husbandry	Modell of a Biogas System	Decentralisation
5 Heat Pump/ Environmental Energy	Efficiency, Cost Comparison: Electric/ Gas Pump	Carnot Cycle, Heat Engine	Cooling Fluid, State of Aggregate		Weather	Building a Heat Pump, Refrigerator	Market Situation
6 Hydrogen/ Fuel Cells		Electrolysis Motors Battery	Electrolysis Thermolysis Photolysis		Production	Simple Fuel Cells	International Relations
7 ~~Geothermal Energy~~ Hydropower Tidal Power Wave Power	Energy quantitative	Mechanics		Ecosystem	Flow of Water Tides Weather Geology Earth Rotation	Types of Waterwheels	
8 Energy Saving	Calculation of Costs of Savings	Heat Transport	Isolating Materials	Human's Energy Need Animal heat	Resource Saving	Isolation of Housing	Energy Crisis Economic Gains Political Decisions

Tab. I: Relation between Renewable-Energy-Subtopics and the traditional School subjects (examples)

(1) KRESS/MIKELSKIS/MÜLLER-ARNKE/REICHENBACHER:
ENERGY - Renewable Energy Resources and Alternative Energy Technologies
(Energie - Regenerative Energiequellen und alternative Energietechnologien)
A Textbook for students of grades 10 - 13
Diesterweg/Sauerländer: Aarau/Berlin/Frankfurt/München/Salzburg 1984 (220 pg.)'

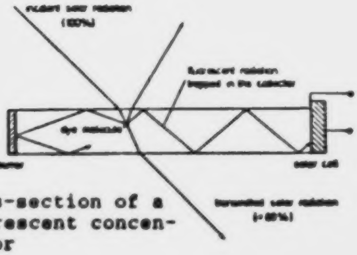
1. Energy Supply in the FRG
2. The Sun as Energy Source
3. Alternative Production of Heat
4. Alternative Production of Electrical Energy
5. Possibilities of Saving Energy
6. Energy Economy and Policy in the FRG

(2) BÜNDER/HÄUSSLER/LAUTERBACH/MIKELSKIS:
Youth Dictionary Technology - Humane and Ecological Technologies
(Jugendlexikon Technik - Menschengerechte und naturverträgliche Technologien)
Rowohlt Taschenbuch Verlag, Reinbek bei Hamburg 1987
(398 pg.)

Major areas of technologies

1. Technology Assessment
2. Food
3. Architecture
4. Household
5. Disposal Technology
6. Energy
7. Traffic
8. Agriculture
9. Medicine
10. Biotechnology
11. Plastic
12. Communication
13. Information
14. Production

(3) GÖTZ:
Solar Energy Conversion with Fluorescent Planar Concentrators.
(A. Goetzberger and W. Greubel, Solar Energy Conversion with Flourescent Collectors, Applied Physics, 14, 123-139 (1977) W. Stahl and Armin Zastrow, Fluoreszenzkollektoren, Physik in unserer Zeit, 16, 167-179 (1985))

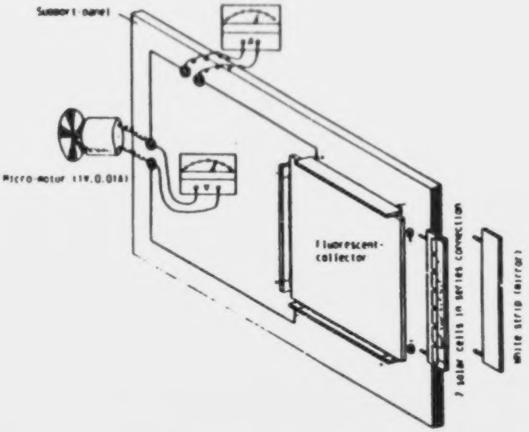


Cross-section of a fluorescent concentrator

Fluorescent Planar Collectors concentrate as much light as possible on small area high efficiency solar cells.
The new collector is transparent plate doped with fluorescent molecules.

The incident light will be absorbed and emitted in the case of Stokes fluorescence with a larger wavelength. If the probability to emission is equal in all directions, part of the light will leave the transparent medium while another part will be reflected back because it intersects the surface at an angle leading to total internal reflection which nearly losness. Thus the captured light is guided within the transparent sheet which henceforth is called the collector. Concentrated light can thus be obtained at the edges of the collector. There it can be converted to electrical energy by photovoltaic cells. At another edge it can by reflected by a mirror.

The Department of Physics at the PH Freiburg, FRG, has developed an equipment to work with this Fluorescent Planar Concentrators in schools.



The Fluorescent Collector is a red sheet. Four small sheets in each case with 7 solar cells in series connection, can be parallel connected. As mirror we use a white strip of plastic material. You have the opportunity for measuring voltage and current. The little motor will work by about 10 mW.

The participants of the workshop from all parts of the world had a fruitful discussion on the energy question and on the related educational problems.

4 WORKSHOPS AND POSTERSESSIONS

4.12 K. Molyneux: Games in S.T.S. education

Introduction

The background to this workshop lies in the article on P. 752 in Volume 2 of the 1987 IOSTE Conference Papers book entitled "Games, Simulations, and Role-plays as teaching strategies for S.T.S.: Science, Technology, and Society", which itself sprang from my recent thesis on Games in Science lessons and relation to Student Attitudes. So, this workshop was to deal not only with the place of Games in STS education but also included the place of Simulations and Role-plays. It also had to be assumed that at this stage of the Conference, participants in this workshop session would not have read the paper mentioned above. Thus, some initial short presentation was thought to be necessary.

Presentation

(1) What are games, simulations and role-plays?

Simply put, games are those exercises such as scrabble or cards which are used for fun and the sole objective is winning; simulations are those exercises or activities that have a situation of simplified reality, such as a simulated excursion to the moon or through the human blood system; while, role-plays are those activities where participants assume the identity of a character and represent that character in a discussion or such like but without there being any script.

These ideas were clarified and exemplified on overhead projectuals, one by the author being shown below:

<table>
<tr><th colspan="6">GAMES
(involving players, competition and rules)</th></tr>
<tr><th colspan="4">NON-SIMULATION GAMES</th><th colspan="2" rowspan="2">SIMULATION GAMES</th></tr>
<tr><th colspan="2">CLASSICAL FORMAT GAMES</th><th colspan="2">SPECIALLY DEVELOPED FORMAT GAMES</th></tr>
<tr><th>NON-ACADEMIC</th><th>ACADEMIC</th><th>NON-ACADEMIC</th><th>ACADEMIC</th><th>NON-ACADEMIC</th><th>ACADEMIC</th></tr>
<tr><td>e.g. Rummy, Bingo, Cards.</td><td>e.g. Valency Rummy, Chemical Bingo, Geological Dominoes.</td><td>e.g. Rubik's Cube.</td><td>e.g. Computer games, Longman's Great Blood Race.</td><td>Monopoly, Chess, Space Invaders.</td><td>War Games, Ghetto.</td></tr>
</table>

The classification above for games attempts to show two things. Firstly, it tries to show the kinds of games that are usually used in a classroom, and secondly it tries to bring out the conscious use of games in academic subjects, as opposed to non-academic use for pleasure or fun.

(2) What has caused the appearance of games, simulations, and role-plays in education?

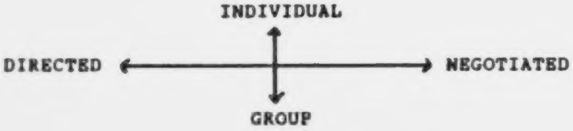
Briefly put, the workshop leader tried to suggest that these activities had arrived in education via the military and business games, but that games are particularly characterized by their universality. Only relatively recently did they arrive in social science education and even more recently in science. It is the contention here that games, simulations, and role-plays sit comfortably in science education (and will sit comfortably in STS education also) because of changes that have happened which include:

- the role of the teacher
- the atmosphere of the classroom

which have been caused by these, as well as other things:

- social aspects in science syllabi
- awareness of the individual student
- modern technology

This has led in turn to a change in types of class activities as shown in the diagram below, where taditional lecture lessons would tend to be in the directed-group quadrant, but games etc. would tend to be in the individual-negotiated quadrant:



In this discussion then, it is contended that how things are taught is just as important as what is taught.

(3) What claims can be made for games, simulations, and role-plays?

Some generalizations that can be gleaned from the literature and made with some confidence are:

Compared to traditional methods, they are

- no better or worse in general studetn learning
- superior in increasing student motivation and interest
- still in doubt about changing attitudes

Other points made by the wordshop leader concerned the important area of student attitudes, since these seem to be one of the main objectives of games etc.. These points were:

- experiments and activity are popular and increase student attitudes to the subject
- student variables (i.e. early years of High School are critical for developing positive attitude to science)
- teacher variables (i.e. the role of the teacher is crucial, with classroom climate being teacher influenced)
- curriculum variables (i.e. innovative curricula of themselves do not seem to improve the attitudes of students towards science)

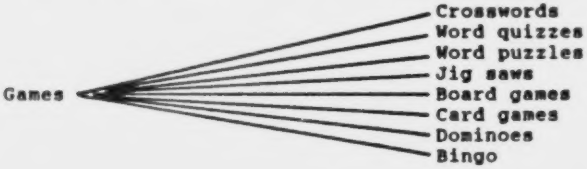
(4) What can games, simulations, and role-plays do for STS?

It was the contention here that games etc. can give the following to STS:

- a variety of teaching techniques
- make students more active learners
- create a lively, stimulating classroom climate
- achieve desirable interest from students
- change the role of the teacher
- bring in language and communication skills
- involve group dynamics

Display

Several examples of games etc. were now displayed and were inspected and discussed by the workshop participants. These are included in the list of examples given below:



- Simulations
  - Simulated excursions
  - Health clinic
  - In-tray techniques
  - Committee work
- Role-plays
  - Panel discussions
  - Debates
  - Court trials

Running of a role-play

In this part of the workshop, five participants volunteered to take part in a role-play, previously designed by the workshop leader. The topic for discussion was "Should smoking be banned on international flights?", and the role cards given to the participants read as follows:

Chairman

a calm but firm character, who tries to give everyone a fair go and will not tolerate rudeness;

A Smoker

aggressive character who sticks up fiercely for the rights of smokers, and feel strongly that smoking should not be banned and is happy with how things stand now;

A Non-Smoker

quiet, reasonable person who represents A.S.H. (Against Smoking Habit Organization) and feels that smoking in the closed atmosphere of an aeroplane is very harmful;

Head of an Airline

confident, cheerful person who is worried about filling seats on flights but is concerned about the possibility of fire in the toilets from cigarettes if smoking is banned in the main cabin of the plane;

A Doctor

rude person who will not tolerate opposition; a smoker who would like to give upt but is addicted; knows all the health hazards of smoking.

At the conclusion of the role play, the panel and other workshop participants discussed the usefulness of the technique and saw it as a useful variation of classroom activity, especially if the rest of the class can be involved via rating sheets or by videotaping of hte panel discussion and class questioning.

Discussion and "brainstorm" by participants

In this last activity of the workshop, the participants were asked to write down (and then share their ideas) where they could use games, simulations, and role-plays in their work, or where they could see games etc. being of use in an STS topic or course. The results of this activity are given below:

- in Biology
  - genetics.....bingo, dominoes
  - botany.......dabates, simulated excursions
  - zoology......debates, simulated excursions
- in Energy studies - card games, role play (town meetings, oil/gas exploration, legislative assembly), debates, word games, bingo
- in Water studies - dominoes, board games, court trials, committee work, simulated excursions
- Other uses - role play in land use planning, solid waste disposal, ecology, dam construction, food additives, pesticides, food.

Summary

This proved to be a lively workshop with many constructive comments from the participants. However, it seemed to be generally agreed that people would like to see the results of games etc. being used in STS topics or courses rather than thinking or discussing how they might be used.

4 WORKSHOPS AND POSTERSESSIONS

4.13 Ray Page: Course materials for technology education for 14-16 year old students

Introduction

This workshop was run to brief conference members about this UK project which was developed from 1972 to 1976 on a regional basis and then formally funded and developed from 1976 to 1980 followed by a dissemination phase under extended funding from 1980 to 1982 nationally. Since then the materials have grown in popularity encouraged by a Government initiative to introduce a technological and vocational element into the secondary school curriculum entitled the Technical and Vocational Education Initiative.

Objectives of the Workshop

These were identified as:

(a) To acquaint conference members with the strategy used for developing the materials of this particular project so that they were relevant to pupils needs; appropriate to teachers' capabilities; and supported by higher Education and Industry.

(b) To look at two or three core modules in detail to explore differences between the teaching of Science, Design or Industrial Arts, and Technology.

(c) To explore how the experience gained by the project team with respect to dissemination and in-service training had relevance to conference members in their communities and countries.

The Structure of the Workshop

The 2 hour workshop was divided into 3 sections. In the first section a brief overview of the project - its development, its materials, and its strategy for dissemination - was given with the help of a handout and OHP transparancies. In the second section 3 modules were looked at in small groups to explore the different qualities needed by teachers to teach technology effectively, with particular reference to problem solving and the assessment of project work. Section 3 was an informal question and answer session exchanging experiences about the development of technology in the school curriculum on a comparative basis.

1. Overview of the project

The project was set up to develop material in a modular form to enrich existing courses in Science (particularly Physical Science) Craft and Design, and Technical Studies (Industrial Arts) with a technological component as well as to offer material on which a structured course in Technology could be based for the age range 14-16 years. In addition the project was charged with trialling individual modules in various courses and schools, as well as groups of modules as part of a structured course in technology for various examinations. It was also asked to evaluate formatively and summatively the impact of the material on the development of pupils' knowledge and attitudes, as well as the reactions of teachers using the material and employers taking on pupils that had been on courses the materials. The following modules were produced by the project:

Energy Resources
Materials Technology
Problem Solving
Electronics
Mechanisms
Structures
Pneumatics
Instrumentation
Aeronautics
Optical Instrumentation
Technology and Society
Digital Microelectronics

The evaluation of the project's materials reveal that they motivated pupils well and produced positive attitudes towards technology and industry, while at the same time increasing their knowledge about technology and its impact on society. Teachers found that the teaching of technology using the materials was demanding, but greatly assisted where they had the support of a Science and Technology Teacher's Centre. Employers were reluctant to accept the Technology qualification at 16+ at first but increasingly saw its merits and in some industries it became an acceptable alternative to Physics.

2. Examination of the Modules

The two modules that were examined in detail were Energy Resources and Problem Solving. It was pointed out that each module took the same form - a Teachers' Guide, a Pupil Reader and a Pupil Work Book.

The Teachers Guides all start with an introduction to the teaching of the module, followed by a set of specific objectives and a conceptual diagram of the module. They then state the assumed knowledge and skills that pupils need in Science, Mathematics, and Craft/Design and a detailed lesson plan for a 10 to 12 week period with two hours per week spent on the module. A list of pupil projects, equipment requirements and notes on building certain equipment, short papers on aspects of the module unfamiliar to teachers, and reading lists completed the Guide.

The Pupil Readers cover the same topic headings as the Teachers Guide but are written to take pupils outside the classroom into the real world to see technology in operation and its impact on society. Thus the energy Resources Reader covers the topics of "What is Energy"?, Converting Energy, Sources of Energy, Using Energy and Measuring Energy. The principle chapters on Sources of Energy and Using Energy cover a wide range of energy sources, including modern developments on aero generators and tidal energy, as well as modern techniques for conserving energy in the home. The Problem Solving Reader on the other hand takes pupils through the problem solving process, giving examples at each stage so that pupils gain a proper understanding of this particular process which is the key to technological activity.

The Pupil Workbooks are intended two underwrite investigational and constructional practical work.

Each module was produced by a group of teachers, assisted by industrialists and experts from Higher Education and material was piloted as it was developed. Teachers were thus inservicing themselves while developing curriculum materials. Usually a smaller group did the final writing and editing.

3. Question and Answer Session

The principal questions concerned the dissimination programme of the project which used the technique of training the trainer and running curriculum development alongside inservice training in a workshop context. Trainers then returned to their schools to set up programmes for their pupils, and then helped other teachers from nearby schools set up their courses, using the trainers school as a model. This was agreed to be an effective method of curriculum dissemination.

Subsidiary questions related to the conflict between Physics and Technology, both claiming a nich in the curriculum the problems of attracting girls into Technology, and whether a two year course at 14 to 16 could have any impact on attitudes.

4. Findings and Recommendations

The group felt that the curriculum development strategy used by the project was a sound one and many delegates felt it was reproducable in their own situation. Some concern was expressed that the publishers of the material were selling the material outside the UK without modification to the local situation, both in terms of needs and content. A number of delegates expressed the wish to remain in contact with the project and there has been subsequent correspondence and visits from delegates concerning the use of the materials in schools in their countries/communities.

4 WORKSHOPS AND POSTERSESSIONS

4.14 Malcolm Plant:
Alternative technology

Introduction

Industrial nations seem, addicted to one form of technology, the one we see applied in developed countries and increasingly in the developed ones. This technology, though providing materials comforts, is sometimes criticised because it disregards the often huge social and environmental costs.

These shortcomings of contemporary technology gives rise to anti-technological schools of thought in the industrial nations. But technologists counter the criticisms by arguing that the undesirable social and environmental side-effects of today's technology are worth the price; e.g. we do have a pollution problem but it is of minor importance compared with the real benefits technology produces. Further they believe that these side-effects can be corrected by careful monitoring and concerted action to restore the environment - the fix-it response.

Advocates of AT argue that not all technologies are intrinscally polluting and that new forms of technology can and should be devised to remedy a deteriorating situation. Thus instead of burning fossil fuels, which produce particulate and thermal pollution, we should develop technologies such as wind and solar power which are intrinsically non-polluting, and which reduce our dependence on increasingly scarce natural resources. Furthermore, it is argued that modern technology is highly complicated and requires a trained specialist to operate it. As a result, ordinary people are deprived of the ability they previously had to control their environment.

The Workshop

In the context of the above background the workshop provided participants with opportunities to explore technological problems which decentralize and localize technology and capitalises on the skills and knowledge of individuals.

The leader of this workshop presented a set of slides that provided a picture of the generally understood views of alternative technologies. This was followed by a video that discussed the controversial proposal to build a tidal barrage across the Severn Estuary in the UK which highlighted the fact that some technological alternatives were not always what they seemed with regard to their impact on people and the environment.

Several aspects of alternative technology were addressed and short practical exercises were set. The activities did not ignore the contribution the new technologies make to alternative technologies, e.g. microelectronics and modern materials, and were designed to alert participants to the local opportunities that exist to use resources that are non-poluting and morally acceptable, and to show that the individual can make decisions about the technology that he or she uses.

A wide range of materials were available for participants to sample and discuss. These were as follows:

1 (a) Alternative Technology; a set of slides introducing AT.

1 (b) Solar-Technology; a solar powered radio shows that sunlight produces electricity.

1 (c) Communications Technology; a communications system showing that optical fibre is an alternative material to copper.

1 (d) Wind Technology; articles describing the generation energy from the wind.

1 (e) Bike Technology; the design features of an All Terrain Bike (ATB) - technology for the individual.

1 (f) Energy-Saving Technology; computer software for developing an appreciation of the nuclear power industry.

1 (g) Nuclear Technology; computer software for developing an appreciation of centralized large-scale technology.

1 (h) Microelectronics Technology; a simple control system for optimizing the use of a solar panel.

1 (i) Food Technology; How can poor countries grow sufficient food themselves? (60 min)

2 Video; Alternative Technology on a large-scale. (15 min)

3 Ashton Island - a problem in renewable energy; a group exercise in selecting appropriate energy resources. (30 min)

4 Is Bigger Better? - a group exercise to examine whether bigger industries are better than smaller industries. (30 min)

Discussion

The final discussion was inconclusive but lively and informative. The group leader proposed that there was no such thing as alternative technology. If technologies were selected with sensitivity to environmental and people's needs, in an ideal world there would be no unwanted side-effects. This view was regarded as unacceptable since many of the consequent side-effects of technological advance could not be anticipated.

From the discussions at this workshop, it was evident that educationalists saw alternative technology as a stimulating area for students to address, but that there was a shortage of suitable materials for students to use and debate issues. Materials such as SATIS (Science and Technology in Society) were regarded as very useful stimuli in this area, as were the videos from the Open University.

4 WORKSHOPS AND POSTERSESSIONS

4.15 Elly Reinders:
Soil, it is kill or cure

The workshop "Soil, it is kill or cure" presented the teaching-learning unit "Bodem, erop of eronder" of the Dutch Institute for Curriculum Development (SLO). The unit has been developed within the project "Integrated Science 12 - 16" as an example of environmental education. The workshop consisted of 3 parts:

1. An introduction with acknowledgements and an orientation on the unit.
2. A video-tape of classroom situations.
3. Conclusions and discussion.

Introduction

The unit is an integration of biology and geography. It was developed with teachers of two schools. A set of eleven criteria for environmental education was developed for selecting the content from the disciplines that is representative for environmental education.
After selection the content, including student-activities as fieldwork, experiments and simulation games, the following structure was made for the unit:

a) An introduction to make students familiar with the important role soil has for organisms.
b) Knowledge and skills in relation to soil.
c) Cycles and ecosystems and man's role in these.
d) Options: different interests that play a role in a local environmental problem.
e) Simulation game: problem solving and decision making.

Videotape

The video-tape showed the try-out of the unit in the Revius Comprehensive school in Deventer. It shows students drilling soil at the bank of the river Ijssel. Students doing experiments with soil animals, perviousness and so on, design a foodweb with paper and destroying it by taking away all the snails in it. A visit to a person of the local government, interviewing citizens living near a polluted field and acting as farmers, officials of the national or local government, actiongroup leaders etc. in the simulationgame.

Conclusions and discussion

In our opinion students have to know the role mankind plays in environmental problems and they should get the skills to make their own decision.

That's the reason why the unit does not only present soil in a scientific way. Students behaviour, value development and decisionmaking are also involved. We think that we made a teaching-learning unit with a lot of environmental education characteristics but implementation of such units is very difficult in Holland.

The discussion in this workshop showed that implementation is the main problem in a lot of countries. So the discussion about implementation dominated the discussion in this workshop. The following points were discussed:

- The problem of organization of fieldwork, simulationgames, research on local environmental problems etc. are too complicated for most teachers. Especially in this period of economizing and strengthening on the job.
- Final examprograms are overloaded and pay to much attention to a scientific way of thinking.
- School authorities don't stimulate environmental education.
- Standards, values and emotions are difficult to cope with for most teachers.

Solutions that were indicated most are:

- improvement of teacher-training;
- involvement of environmental education in national science (exam-)programs;
- financial support and structural stimulation of environmental education by the government.

4 WORKSHOPS AND POSTERSESSIONS

4.16 Kent Rossier:
Science, Technology and Society. A modular senior high school laboratory science course teaching science processes and thinking skills in a social context

These materials were completed this year (1987) by teachers of the United States Department of Defense Dependents Schools. The course materials consist of 10 modules, each with a Teachers' Edition and Student Materials, supplemented by a Teacher's Resource Book. Samples of these materials were displayed at a poster session.

The materials were developed to increase instruction in the process skills of science, and to make conscious efforts to improve the thinking skills of students. American teachers of conventional courses, e.g. biology, frenquently attempt to "cover" the content of a text book and have little time for teaching the science process and thinking skills. Accordingly, topics were chosen for the STS materials which would favor keeping the focus on those skills and attitudes that will serve the citizen and technician as well as the future scientist. The project was initiated by the DoDDS-G Science Coordinator, Kent ROSSIER, and the Senior Editor was Dr. Faith HICKMAN.

The modules are titled: Always Room for One More? (populations), BioMedical Technology, Energy, Extra-Terrestrial Settlements, A Healthy Balance (a systems investigation), Living Room (how people and society use territory), Too Good To Lose (endangered species), Transportation, Water And Civilization, and Your Money, Your Choice (informed consumerism).

Some common strands running through the modules include; generating data, interpreting findings, identifying values, and describing consequences of decisions.

The course materials have been adopted by 18 American schools in 4 countries. Further information is available from Mr. Kent Rossier, Im Jungehag 17, D-6238 Hofheim, West Germany.

4 WORKSHOPS AND POSTERSESSIONS

4.17 Edward Shaw:
Effective use of microcomputer simulations in elementary science classrooms

Content of the Workshop

Research indicates that computer assisted instruction (CAI), is an effective teaching strategy when used with regular classroom methods of instruction. In addition, student experience with CAI leads to an improvement in achievement and positive attitudes towards learning (HALLWORTH & BREHNER, 1980).

Computer simulations are a type of CAI applicable to areas such as the science and discovery labs in mathematics (AIKEN & BRAUN, 1980). Simulations are intended to authentically model reality, to provide a larger role for decisions in determining outcomes, and to form the basis for discussions of structure, functions, and processes in the "real" world (SHAY, 1980). It is important that the classroom teacher have some direction in deciding what is the best method to use simulations in elementary science classrooms.

A need exists to educate teachers on the most appropriate method for the utilization of simulations in the elementary science classroom. From this workshop, participants will receive practical information for the implementation of simulations.

Set-up:
Using content-oriented simulation such as: ODELL LAKE, ODELL FOREST, QUAKES (Minnesota Educational Computing Consortium, 1980) and process-skill oriented simulations such as Moptown Parade (The Learning Company, 1982) and The Factory (Sunburst Communications, 1983) and an Apple IIe with a large color monitor (61 cm diagonally), the presenter introduced the sample simulations, involving participants in the selection of appropriate answers to questions posed as problems were solved.

Main Topics of the Presentation

Participants were introduced to the above named hard- and software to demonstrate the practical classroom applications of CAI. Participants were exposed to a preferred lesson plan format designed for teachers who may not have access to all the documentation accompanying a simulation. Participants left with an increased knowledge of methodology in the use of simulations in the elementary science classroom.

Findings/recommendations

From the post-presentation discussion several recommendations evolved: first, the need for consideration of national production of software that would have topics more appropriate to the needs of the country; second, the need for more information on the current status of microcomputer software, especially simulations, throughout the world; third, the concern, when dealing with small children, of anthropomorphism which teachers and software can convey to students; fourth, the feasibility of buying software, including the expense involved in having it translated, versus a country's capability or interest in producing its own software.

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4 WORKSHOPS AND POSTERSESSIONS

4.18 Harriett S. Stubbs: Acid rain/air pollutants

The theme of this symposium "Science and Technology Education and the Quality of Life", is most appropriate when we think about air quality worldwide. The "impact on everyday life situations, the decisions the responsible citizen has to make when dealing with controversial societal issues, and the impact on future careers" - all of the three themes selected by the organizing committee - fit immediately into the focus of what and how air quality will be met by each and everyone of us.

I should like to quote Dr. Ellis B. COWLING (1985), President of The Acid Rain Foundation, who in recent Albright lecture at Berkeley included the following information:

> "Everything human beings do on a large scale influences the chemistry of the atmosphere and in turn the health and productivity of the ecosystems on which the abundance and quality of our life depends. The largest of all human influences on the chemical climate result from combustion of fossil fuels, urban development, and clearing of land by burning of natural vegetation. These activities include: generation of electricity, refining and use of petroleum and petrochemicals, industrial processes of many sorts, use of transportation vehicles, space and water heating, incineration and decomposition of sanitary and solid wastes, use of explosive devices in peace and war, launching of space vehicles, and agricultural and silvicultural operations involving plowing, cultivating, spraying, disposal of plant and animal wastes, and burning of farm and forest residues."

But acid rain must be recognized as only one special feature of a series of more general subjects that include:

1) "The emission, transport, transformation, deposition, uptake, and exchange of natural and man-made chemicals between the atmosphere and terrestrial and aquatic ecosystems;
2) Wet and dry deposition of beneficial nutrients and injurious gases, aerosols, and dissolved or suspended substances in rain, snow, hail, dew, and fog;
3) The short-distance and long-distance transport of air pollutants from one state or nation to another;
4) The role of human activities as a potent force in the biochemical circulation of matter in the earth; and
5) The responsibilities of human beings as managers of industrial societies and custodians of the natural resources of the earth".

The six most important primary air pollutants are sulfur dioxide, nitrogen oxides, toxic elements such as lead and fluorine, and a wide variety of volatile organic compounds, carbon monoxide and particulate matter. The two most important secondary pollutants are photochemical oxidants (especially ozone) and acid deposition. Airborne acids and particulate matter can occur as both primary and secondary pollutants.

Acid rain/air pollution is an international, interdisciplinary, multi-disciplinary, continually changing issue. It is politically charged. It is no longer enough to think in terms of acid rain - rather we must include all of the air pollutants. For you as science educators, how can current highly technical scientific information be translated and placed into ongoing curriculum? What materials do you need in order to teach about a current environmental issue?

In 1978-79, a questionnaire was distributed to randomly selected Minnesota science teachers in life, earth, physical, environmental sciences, biology and chemistry. Nine of the survey questions requested information concerning what materials teachers had used or would be willing to use to teach about a current environmental issue of acid rain. The four items selected by teachers who would teach this issue in the future were:

1) 16mm film
2) Informational packet
3) Reading assignments with questions, and
4) Lab activity.

This information was important, for in 1978, the term "acid rain" was not a common term. This topic was "new" to the classroom teachers.

Questions which may be asked are as follows: Are these same data applicable to other issues? Is this an important message that an informational film should be developed first and a new topic? Is there a greater likelihood that the topic will then be introduced into the classroom? These questions are topics for future research.

In 1987, there are many more resources available on the topic of acid deposition. The materials of The Acid Rain Fundation have been developed with a strong science base and are meant to be inserted into ongoing curricula. The activities are concerned with the process of science with societal implications. Now, curricula has been developed in Sweden, the Netherlands, Canada, and the UK.

In developing materials and teaching a topic with an STS theme it is important to include:

1) Definition of issue, with it's history and background.
2) Many different viewpoints - the topic would not be the same if it were an easily solved problem. Therefore, there will be many different views from different groups.
3) Decision-making on the part of the student is an important component. JOHNSON & JOHNSON, University of Minnesota, have an important role-play activity reaching consensus at the end.
4) The topic is an "ongoing issue". That is, the science and knowledge base changes so that the teacher cannot expect to "learn it all". There are continual changes in the scientific, political and other arenas over time.
5) There is a strong interdisciplinary scientific base.
6) Answer(s) and solution(s) not available.

We have attempted to address the issue of acid deposition in many ways, in many different publications to many audiences. Soon we shall have completed materials on the effect of air pollutants on forest ecosystems, and hope to move toward global climate change.

We hope that the acid rain example can serve as a model for education/information materials on any issue.

Many materials for classroom use have been developed internationally. A survey of available curricula, resource materials including scientific literature, popular literature, posters and audio-visuals were presented.

Materials can be used in elementary, middle, junior and senior high school and in life, earth, physical, environmental sciences, biology and chemistry.

5 GROUP REPORTS

5.1 Roland Lauterbach, Jayshree Mehta: Main working group: Science education

Introduction

More than fifty papers were submitted, presented and discussed in the Working Group on Science Education. They are compiled as Volume I of **Science and Technology Education and the Quality of Life** (RIQUARTS, K. 1987). A chronological review of the presentations would neither do justice to the individual contributions nor be in the spirit of the conference. The widely ranging topics covered and issues raised were not to be confined to the conference theme, although an attempt was made to relate them to the three subthemes guiding the discussions. In retrospective, however, the efforts to bridle expansive issues and forceful ideas into a joint venture of conceptualizing a set of propositions for future actions appear fairly successful.

Therefore, this report takes on the format of an interpreted synopsis selecting from the papers and discussions those ideas, issues and examples which seem to express the common intentions of the participants best. We are quite confident of not merely having reproduced our personal views. At the end of our sessions we pooled what we considered most valuable to retain and develop for the future. Finally, we even dared to set priorities knowing that this in itself will be an issue. To mark the status of the decisions, they are still called trends in this report.

What do we mean by quality of life?

1. The Concept of Quality

The promising title of the symposium was prompted by the assumption that science education can contribute to the improvement of our lives. - Its quality, not its quantity was envisioned. The underlying question in our discussions searched for the meaning of this quality, accepting more and more that the answer was not to be given once and for all. It was an historical question and as such it would always receive historical answers. Obviously, for an individual, be it child, teacher or parent, the answer will have to be biographically determined. For one person it will be receiving sufficient food for survival, for others it may be the conditions of choosing from a variety of foods. For some it will be the know-how of shelter technology, for others it is the availability of water, light and disposal systems. And as far as education is concerned, quality may be measured by chances for going to school or learning to read and write or getting degrees or experiencing science as enlightenment. These possible characteristics of quality are not subjective but objectively linked with the society in which a person lives and grows.

From this follows that quality improvement will mean different things in different societies if we look at the observables. While an agricultural science education project in the rural areas of Mexico focusses on intensive methods of yield increase, a project of the same title in Germany deals with the renaturalization of farmland into grass and forest areas. Similarly, a programme of science for citizens in

India concentrates on community activities for mothers and young women, while a Danish programme elaborates on biotechnology in order to have the people participate more competently in political decision-making on issues of gene manipulation.

Beyond the apparent differences, we discovered that we had many things in common. Just to mention a few: Our discussions revealed our intention of improvement to be

(1) democratic, i.e. for all people,
(2) non-destructive, i.e. having no harmful effects on others,
(3) compensatory, i.e. preferencing those at a lower quality level,
(4) need oriented, i.e. satisfying the individual needs for humane living (and not being guided by the political goals of, for instance, national prosperity to the disadvantage of those with the lowest income),
(5) convivial, i.e. favouring common use and availability for all without suppressing anyone,
(6) ecological, i.e. optimizing the natural conditions for life and nature's development,
(7) moral, i.e. promoting the basic rules of humane living for all without imposing form values upon others.

But on practical terms we did not ignore historical reality. Although, there appears to be little objection to the Charter of Human Rights the United Nations have agreed upon, we remained aware that the reality in all of our countries is far from achieving these rights in all areas of life for all people.

2. Areas of Exposure: The Sub-Themes

While searching for contributions science education could make to the desired end, we concentrated on the three sub-themes of the conference: everyday experience, citizenship and careers. As we successively proceeded from one area to the next, from the most general and most common to the more specific and more divided, our conceptualization progressed as well.

We identified everyday life as most fundamental for any (science) education, being the ever-present materializer of any values, concepts or processes learned as personal knowledge through repeated personal experience.

Public life requires a more sophisticated and rationalized instrumentarium of science knowledge for active and effective citizenship. Saving only one's own plot from flooding is hardly feasible when a dam is needed to control the river. This type of science knowledge grows probably best on a substantial fundamentum of personal experience, but it has to go beyond it in conceptualizing intersubjective validity of values, concepts and processes. The heavy use of pesticides and herbecides may improve crops at one place for a few years but it will - in the long run and if applied everywhere and by others as well - ruin our subsistence. Because of that, science based agreements have to be found, laws and regulations have to be established which surpass momentary individual interests in favour of our and our children's humane survival.

When asking for the contributions of science education to careers of individuals care must be taken to avoid too narrow a view on specific science or science-related occupations. Otherwise, one might be missing out on viewing working life as part of everyone's contribution to common productivity for the above mentioned humane survival in our system of divided labour. Knowing how different goods are being produced, under what conditions and with which effects this happens, will have to be part of any science education directed at improving the quality of life. For instance, if energy production and use is to be improved to this end, economists and adminstrators will have to know enough about the science and technology necessary to understand the present and judge the future utilizations. Otherwise they will calculate and decide with disfunctional data improving the past while degrading the future. Or the career chances for specialists in laser optics may guide science education into preparing many young people to become productive members of the SDI-teams.

The interlocking hierarchy of everyday life, public life and working life did not permit a clear separation of the answers science education could offer to the question on how to improve the quality of life. We even were forced to transgress the subject view of science education. Nowadays a specific science has to be thought of together with its existing and potential technology, and it also has to be conceived as being at the same time socially determined and a social determinant. Thus, the most promising answers are mainly inter- und trans-disciplinary as far as the individual school subjects of physics, chemistry, biology, geology and geography are concerned.

The attempted answers are based on practical experience reported in the papers and were reflected in the discussions of the Working Group. But they are still fragile projections of desirable possibilities into reality. We'd like to affix to them the label: Handle with care.

Trends in Science Education

More than 50 papers were presented showing diversity and richness of developments in science education from all over the world and covering education from early childhood to adulthood, from single classroom events to educational policy decisions for a whole country. In retrospect, it seems surprising that four trends clearly emerged which turned out to support each other in a promisind concept that we, the participants, felt to be worth promoting in a joint effort.

1. Science for All

Today science education all over the world is directed at all students. It is concerned with enhancing their understanding of natural and technical processes and developing their creative and productive potential. These are considered indispensible prerequisites for upgrading the quality of life. But for actual improvement of living conditions students will have to complement knowledge and problem-solving capabilities with a productive social commitment by

- taking the future in their own hands,
- participating in public decision-making and
- raising the quality standards of productivity.

At the programmatic level a far-reaching consensus in the intentions of science education can be identified. But as the motives for implementing them differ among cultures, different curricula have resulted. Basically, two cultural contexts dominated the trend setting.

Cultures with a long tradition of natural sciences and industrial technology usually also have a long tradition of science education in their state-run school systems. Science and technology have become constituents of that culture as its sub-systems and motors of change. But as there have been positive as well as negative effects on society and environment which can be traced to science and technology, the reconsideration of science in education reflects a strong critical component as far as achievements of science and technology are concerned. This awareness induces a redefinition of science education to include the rediscovery of nature (as a necessary environmental prerequisite for human development) and the reconstruction of technology (as necessary constructive capability for humane and convivial existence). Although the reality of science education in these cultures is still dichotomous, controlling scientific and technological development clearly emerges as a characteristic trend for improving the quality of life. But as productive and responsible control requires higher qualifications for all people in a society, it follows that science education has to be extended to reach everyone.

Cultures for which the complex of science and industrial technology appears as external demand or force, also react dichotomously. On the one hand, science and technology are perceived as being part of a foreign culture overpowering traditional culture and thereby destroying cultural identity. On the other hand, they are welcomed as chances for eleminating the natural disadvantages and social deprivations by controlling, exploiting as well as developing nature. Here, the emerging trend favours a positive attitude towards the instrumental character of science and technology, while their formative influence on culture is critically viewed, with demands made of science education to arrange for their cultural fit.

In these contexts science education for all is proclaimed as well. It sets out to optimize cultural integration and avoid a separation into two cultures.

Both of these developments were considered desirable complements for improving science education in general. Thus, the conception of a Core Science Curriculum for All was proposed on which common understanding and communication could build. It should reflect the different cultural motives for science and technology and enhance their transformation into educational action for the respective political and cultural contexts.

2. Science Education in the Community

Political and education programmes are desirable as guidelines. But the intended curriculum will differ from the implemented one. The proof that science and technology can be productive and promising for cultural development will have to be given in the places where culture unfolds - the communities. At this level of cultural activity science and technology has to

- become practical for everyday living,
- offer enlightenment and guidance for public decision-making, and
- improve productivity and quality in everyone's working life.

As a result of some promising evidence that the transformation of general science knowledge and technological know-how to the community level is possible it is proposed to implement the science curriculum in consideration of the needs existing in the different communities. For a possible Core Curriculum this will require local adaptation and extension.

3. Science Education for Women

A Science Education for All will have to be conceptualized as science education for girls and women. Empirical research and various development programmes give clear evidence favouring this approach. Girls and women have been characterized as the "missing half" of science and technology education. It appears that the community orientation for science education is a valuable contribution ot this end and vice versa.

Some of the major evidences and arguments can be summarized as follows:

(1) Especially for physics and physics related technology education girls clearly indicate lower interest and show less knowledge than boys. Textbooks as well as the behaviour of teachers (male as well as female) favour the boys.

(2) Certain conditions for science learning, e.g. girls represented in textbooks, personal relevance of subject matter, everyday usefulness of topics, or phenomenological experiences, increase the interest of girls in science and technology.

(3) Improvement of learning conditions in science for girls positively affects science learning for boys too. It follows that such an educational strategy improves science learning in general.

(4) Women are hardly represented in scientific and technological occupations. Thus, improving occupational chances is a desirable complement to improving science education to this end. But this is a cultural and political issue of some magnitude.

(5) The social, cultural and economic importance of mothers with regard to education (including science and technology education) appears to have been valued far too low. In general, mothers will take care that their children (boys as well as girls) experience better, at least the same, education as they themselves have had.

As obvious consequence of the existing discrimination of girls and women in science education it is proposed to investigate science curricula, science teaching and teacher training with the purpose of reorganizing them to encourage girls in learning science and dealing with technology. In addition, mothers (and girls as potential mothers) should receive special support and attention in the frame of science learning and science use in community approaches.

4. In-School and Out-of-School Learning

The above approaches for improving science education can be supported and extended by a complementary system of in and out-of-school learning opportunities.. Obviously, a programme of science education for all cannot confine its activities to the state-run school system. In many countries formal education does not reach all children. And too often children will leave schools after three or four years of education. The emphasis on reading, writing and mathematics rates science educaton at best fourth. The insufficient training of teachers in the sciences adds to the dilemma of administering a full scale science education programme to all children. But even under fair conditions the formal education systems will have to satisfy the programmatic aim of educating every child in science by compensating social deficits. Not only girls need special attention, so do - independent of gender - children from urban areas, from culturally deprived families or children with individual handicaps. Out-of-School approaches are sometimes offered for these children. But mainly there are offers for children with particular interests in science and technology: chances to excel or just have fun, like science and invention fairs, science olympiads or other competitions, science and technology centers with workshops, hands-on museums and libraries, or science clubs in cooperation with small and sometimes large scale industry.

Similarly, the idea of community education requires a non-formal system even if the state-run schools are involved with facilities, equipment and personnel. Women's clubs, science busses travelling cross-country, science centers and libraries, or adult education systems offering further education in science and technology are increasingly available. Special projects in deprived areas prove the inventiveness of the project members by showing how science and technology can become productive and valued as knowledge and know-how for solving problems of communal survival and improvement. Unfortunately, optimal balances between centralized and decentralized decision-making, organization and executive control are difficult to establish.

The cultural diversity does not allow precise proposals for out-of-school science education, except the promotion of all activites supporting it. If the core curriculum is institutionalized through the formal school system, a non-formal system should guarantee its extension to those not reached by formal schooling. In addition, a variety of non-formal organizations could offer science and technology as cultural diversification and cultural potential for everyone - similar to sports, music, dance, etc.
Public media like radio, television, newspapers or periodicals would be part of this joint effort.

5. Potentials

Our report cannot be complete. But it would miss one of its most important functions, if those trends are not made explicit, which either have had representatives too modest to claim strong attention or did not yet fit into the perceptual and conceptual schemes of most of us. Sometimes, the retrospective review identifies anticipations of developments which in the course of action were hardly thought to be more than small disturbances or exotic ornaments. Hopefully, they will find the adequate climate to develop their education potential.

(1) Computers in Science Education: Rated against the high attention this topic receives in industralized countries, the conference contributions were only marginal.

(2) Peace Education: The threat of human survival through magnifying potentials of high tech weapons based on sophisticated science and the role of scientists in this proliferating development appeared in the discussion. But compared to its existential importance it seemed hidden in a taboo zone.

(3) Child Orientation: Viewing the child as active learner often went out of focus due to the complexity and magnitude of some national problems.

(4) Project Work: Science education no longer is confined to individual science courses, but increasingly appears as constituent of interdisciplinary projects.

(5) Open Problems: Science education has begun to take on some complex problems with open outcomes. But so far, school science (including university level) is still reluctant to take the lead.

Conclusion: Teachers

Expectations of improvement are tightly connected with existing and anticipated teacher qualifications. And here the problems accumulate. Well trained science teachers are rare, qualified science teacher trainers are scarce. And teaching science through textbooks is counterproductive, if it is not complemented by activity-based learning arranged and supported by qualified teachers. It suggests knowledge where verbal information prevails leaving the student incapable of turning what has been learned into productive action.

The burden on the teachers will be heavy, in those cases probably too heavy, where they are expected to become teachers of the whole community leading its people towards a science and technology oriented culture giving proof of quality improvement.

In consequence, each society has to assist its teachers in their own efforts for extending and upgrading their qualifications to meet the challenge of improving the quality of life via science education. Action needs to be taken at all levels of the education system. Some of the requirements are

- institutionalizing pre- and in-service training to include, e.g.
    - broad general education of teachers
    - thorough science background
    - interdisciplinary projects dealing with technological, economic and social issues
    - pedagogics, didactics and methodology
    - communicative and interaction skills

- improving the material conditions of teaching and learning, e.g. buildings, facilities, equipment, media

- setting up organizational support systems for the schools within and between communities
- establishing research capacities, to monitor, analyze, reflect and, if necessary, reorganize development.

In addition, the social frame conditions for teachers also need improvement like raising their social status and offering professional incentives for extra efforts. These propositions are not new. Many countries have recognized that education has a vital function for their society. But because educational innovations require time and their results are difficult to judge, education often turns out looser in the competition with other social sub-systems. Politically desirable short term effects are indeed hard to get. It takes at least ten years for the first new generation to leave school and another ten years to prove their qualities. And yet, there is no better investment for a society than improving the education of its children. And there is no better advocate, manager and executor of this task than the dedicated and well-trained teaching professional.

5 GROUP REPORTS

5.2 Geoffrey Harrison:
Main working group: Science education

The Working Group on Technology Education related its received papers, on Everyday Life, on Responsible Citizenship, and on Careers, to a proposed underlying educational framework for School Technology as an overall concept.

A draft of this Educational Framework was presented on the first day and examined in parallel with presentations on fundamental issues for School Technology, namely; the moral dimension and staff development; the nature of usuable concepts and how they are used; progression from the "Early Personal Technology" of small children to the sophisticated technologies of adults; the nature of interactivity between teacher and pupil; and worldwide perspectives on contemporary developments in technological education.

The draft Educational Framework, expanded to accomodate these and other issues, was then discussed with a view to identifying those questions which needed to be answered in any country considering how it might best develop its own educational programmes to meet the challenges and opportunities of Technology.

Finally, the Working Group drew on the very wide range of experience of its members in arriving at recommendations for programs which it believed IOSTE should pursue in the future.

A: SYNOPSES OF PAPERS PRESENTED AND RELATED DISCUSSIONS

All the papers referred to were published in Volume 2 of the pre-symposium publication. For details see chapter 8.

The Educational Framework

1. An Educational Framework for School Technology
   (Peter EDWARDS)

Definition of Technology
Accepting that individual circumstances may call for more definitive statements, the "PURPOSE; PROCESS; RESOURCES" model is sufficiently generalisable to accomodate them all: "Technology is a disciplined PROCESS of using personal RESOURCES of scientific and other knowledge and skills to achieve human PURPOSE".

Aims of Technological Education
While "aims" can be stated in simple terms, the achievement of items on a progressive scale, throughout education is complex. In stating three fields of aim, no hierarchical status is implied, for the aims interact with each other in a complex spiral manner. Nevertheless, in thinking about aims it is helpful to explore the progressive development of the three fields of:

- AWARENESS, of the potential of technology, its side effects and the responsibilities of individuals and society for its control,
- CABABILITY, meaning the capacity to tackle real technological problems with a holistic attitude in which competence, value judgements, use of resources of knowledge and skills, anticipation of adverse side effects, and the determination to achieve a satisfactory target are all brought together in a single enterprise.
- RESOURCES, to be called upon when engaging in the processes

of Technology, including those of knowledge, intellectual and physical skills, experience and personal qualities such as determination & resourcefulness, imagination, intuition and innovation, observation, perception and sensitivity.

Relevance of Technology Education

The three thematic areas of the 4th Symposium provide distinct kinds of relevance:

- relevance to everyday life
- relevance to the role of a citizen
- relevance to future career potential.

Pedagogy

The autonomy of the individual being the ultimate target, the style of teaching and learning needs to become increasingly pupil-oriented, calling for more confident teachers who can allow pupils freedom of action and can readily accept that they are not necessarily the fountain of all wisdom.

2. Pupils' lack of sophistication leading to applications of unapplicable principles in agrotechnical contexts.

(Amos DREYFUS)

Technology is the ideal context for science concepts. Pupils may be expected to apply a particular concept to a particular problem, but in reality, they are likely to use a different concept, and get it wrong! Teachers cannot tell children when not to use a concept. The necessity of a good match between the parameters of a particular problem and the features of a concept being used was emphasized. The analogy of the lock and key was very clear. The paper raises some fundamental questions about the usability of the concepts we teach as resources for use in technology.

3. Some developments in technology education in Australia.

(Ken ECKERSALL)

The development of technology education in Victoria would accept the definition of technology devised for the framework but would emphasize the moral issues. He stressed the importance of practical activities in all subjects with specific concentration in certain subjects. Although it is generally agreed that technology should be integrated throughout the curriculum, certain conditions were necessary. There is a need for a designated coordinator. There is a need for systematic staff development and a requirement for appropriate facilities.

4. Technological Education for Younger Pupils.

(Ray L. PAGE)

In speaking of the developments in Bromley, United Kingdom, RAY referred to the need for a planned progression from the primary to the secondary phase of education. There is a very early awareness of technology amongst small children - call it "Early Personal Technology". Building on this through science, design and to an extent the humanities develops resources for the full development of capability through parallel developments in Science, Technology and Design.

5. Technology and improvement of education for minority and handicapped children.

(John NIMAN)

Interactivity between teacher and taught is highly important. The difficulties of establishing this accentuates the disparity of achievement amongst ethnic minorities in New York. The use of a combination of high technologies (video discs and computers) enables the greater provision of appropriate interactive learning for minority populations particularly in the field of Technology itself.

6. Technology as part of general education.

(Faqir C. VOHRA)

A history of the involvement of UNESCO in the development of the technological education in schools during the last 25 years is full of interesting lessons. From the earliest time, there was agreement that technology should form part of the curriculum of all children. But a further survey showed great variation in the unterstanding of what Technology meant; from Art and Craft to Educational Technology to Industrial Arts. Currently an experiment is showing that countries given the same brief for development are responding in very different ways. There is a difficulty in the concept of Technology as a separate study but a feeling that there is a link with science which helps to form a bridge between schools and the outside world.

7. Discussions on the principles of an Educational Framework

Emphasis was placed on the several humanity aspects: the essential human purpose for technology; the role of technology in the cultural development of mankind; the human feelings, intuition and creativity which influence, and are influenced by, technology. The danger of having too broad a definition was recognized but, equally, it is important for any specific subject field to have a sound fundamental philosophy on which to base its specificity.

On both a large (year by year) and small scale (minute by minute) progression in the achievement of the aims should be planned for. Whatever the form of technology in the curriculum (as a separate subject or subsumed in other subjects) there must be cohesion between the planning and delivering of the different parts of the curriculum. Recognizing that our schools comprise individuals, the special needs of particular groups should be planned for. The possibility of a hierachy of aims was considered but the general view was that the spiralling interaction of the aims would continually place them in a different order.

The notion of "capability" is an uncomfortable one. It could be seen as a "resource". If it is, it is a different kind from that of knowledge, the possession of which does not imply the ability to use it to make a decision to bring about a particular end result. In the case of Technology "capability" calls for this ability as well as that for tackling problems in the holistic manner.

There was a pursuit of the answer to the argument between Technology as a separate subject and an integrated approach. There is a paradox. If Technology is so important that it goes right across the curriculum it will lose its focus and not exist in any form. The curriculum cannot be planned piecemeal. There is a need for a focused discipline of technology. It is realized that the precise method of inclusion in the curriculum is dependent largely on local pressures and constraints. What is important is what children learn and do. Regarding curriculum structure, whatever subject or subjects are used to carry technology, they must have a fundamental discipline upon which to fall back.

Technology Education and Everyday Life

1. Technology for Rural Development: An Indian Experience.

   (Saurabh CHANDRA)

Appropriate technology can have beneficial effects on relieving poverty in a rural environment. There did not appear to be an absence of appropriate solutions to problems existing in the development of an agricultural society, rather there was a difficulty in encouraging beneficial attitudes amongst recipient populations to enable positive acceptable and appropriate application of these technological solutions. Key individuals should be extracted from the recipient community, in order that they would receive intensive training, and, on return, would disseminate their expertise and experience gained. This, along with "distance learning" using satellite television, was seen as means of alleviating such difficulty.

Discussion concluded that technology education should be "appropriate" to the local requirements, and that historical and modern technological achievements should be brought into focus in any implemented course or integrated curriculum approach. Teaching about the impact of technology on everyday life, and the relevant issues implicit in this, is essential. Pupils should be assisted in understanding the consequences (anticipated and unexpected) of technology in society.

2. Technology in Pupils' Everyday Life. Effects of course material on the pupils' attitude towards technology.

(Marc J. de VRIES and F. de Klerk WOLTERS)

Along with an evolving concept of technology education amongst teachers is a need to analyse the perceptions amongst boys and girls of their concept of technology and their attitude towards it. In many cultures technology is seen as the domain of man (as opposed to woman). Different cultural backgrounds bring different concepts and attitudes in boys and girls (this being a concequence of society assigning roles to boys and to girls). It was seen that technology education faces similar problems to those faced by science, in that there are more negative attitudes expressed by girls than by boys.

This paper also raised the issue of teacher provision. Wherever technology education is placed in the curriculum, teachers will be needed for it. Where do they come from? If we simply retrain science teachers then we are denuding science of its teacher resource. Attracting more into the teaching of technology is one rational solution. Whatever the teacher resource, various interpretations of technology education within the framework will develop. These interpretations should have elements that include: a problem solving process, knowledge of a resource including energy and materials together with an understanding of control, along with awareness of technology's interaction with society (local and international). Whenever decisions are taken as result of a problem being faced then value judgements (moral, aesthetic, economic, technical, social, etc., etc.) will be developed and communicated.

In discussion it was agreed that any means of testing attitudes was uncertain. Questions could bias responses and different population samples were likely to have had significantly different experiences leading to diverse responses and unsound conclusions. Nevertheless, others in the group had come to similar conclusions as a result of their own research.

Technology Education and Responsible Citizenship.

1. Establishing a linkage mechanism for technology transfer between National Science and Technology Authority (NSTA) - Science Promotion Institute (S.P.I.) and the Ministry of Education Culture and Sports (M.E.C.S.) schools.
   (Adoracion D. AMBROSIO)

The theme was a project in the Philippines which sought to accelerate the transfer of technologies from research and development institutes using a linkage mechanism which included feedback loops. Factors operating in the transfer which were considered in a training programme for teachers, developed to accomplish the transfer, were outlined, namely use of indigenous resources, values and awareness of the populace. A flow chart summarizing the work of the project was discussed briefly. The monitoring feedback loops will provide information on the programme's impact.

2. Teaching technology - Refrigeration, an example from New Zealand's economic history.

(Mark COSGROVE)

An experimental project on teaching the "scientific" technology of refrigeration in New Zealand using a "bottom-up" approach with fifty-three sixteen year old students was described. The philosophy and psychology were outlined. People, technology and science were significant in that order. The strategies and outcomes were enumerated. Control systems were only identified by students after a considerable period of time, girls showed unexpected attitudinal gains and long-term (one year later) positive effects were detected. The means of the approach suggests there is value in teaching technology to all students, and science only to some. Follow-up studies are planned.

3. School mathematics, advanced technologies, and responsible citizenship.

(Douglas H. CRAWFORD)

Mathematics without reference to technology is considerably diminished. A sequence of studies begun in 1979 was traced to establish a pivotal position that measurement is a critical control theme. Follow-up studies provided data leading to redesigning the school mathematics enterprise, based on the use of mathematics as a tool and resource for solving real interdisciplinary problem. The focus of the content should be everyday and global problems to enhance responsible citizenship.

In discussion it was restated that for most people mathematics must be useful, and that mathematicians must free school mathematics from over-dependence on university mathematics. The failure of school mathematics was evident in the attitudes of adults and their inability to use it. Some glimmers of light are visible in the move towards estimation and approximation in contrast to emphasis on a single correct answer and methods. Changes in attitudes are critical. Criteria for aims and content emphasis could probably be derived from the contexts in which mathematics is used (individual in society, work, leisure, and the needs of society). Perceptions of mathematics by elementary teachers and parents are distorted and confused and governments do not take the problems seriously enough. Emphasis on mathematics for use in a technological society offers a more effective approach than a heavily discipline-oriented one.

4. Technological development and the raw materials procurement in the developing countries.

(Gregory O. IWU)

The question of procuring raw materials for technological development in developing countries, especially Nigeria, was examined. Over 80% of the semi-manufactured and semi-processed materials for feedstock uses is imported as raw material. There are powerful implications for developing countries - both government and people - which are vulnerable to the dumping of materials by Western countries, resulting in high unemployment. Indigenous products should be domestically processed. Attempts to improve technological capabilities are underway by reform of the educational system to include explicit emphasis on technology at a pre-university stage. The example of Guyana being able to use local cassava flour as an acceptable substitute for imported wheat flour in processing bauxite was cited. Educational reform must be accompanied by attention to political and ecnomic aspects.

Disussion in the afternoon started from the questions "What can technology education do for the developing countries?" It was stated that it should relate to existing needs, and that work already done, or in process, in the more developed countries (M.D.C.) integrating curriculum would be useful for less developed countries (L.D.C.). Work in the United Kingdom on the Core Curriculum, in Holland on Physics and Technology (de VRIES), Victoria, Australia (ECKERSALL) and Refrigeration (New Zealand, COSGROVE), as well as in the United States of America and several other countries including India and Thailand were cited as possible sources.
The use of disciplines as resources for developing curricular materials in Mauritius (e.g. electrical appliances, compost making) were mentioned, and various factors of significance identifies (need of frameworks, implementation strategies, examination of outcomes, and technological capabilities in the L.D.C.). Caution should be exercised as implementation models might over-simplify real situations. This led to the suggestion that parameters relating to areas of content might be listed and lead to a set of patterns.

The next phase was one of brainstorming to build up a list of PURPOSES and CONTENT in technology education. This kind of activity was done as a "curriculum web" in Victoria, Australia. A partial list was developed, but, after a while, the feeling emerged that this might better be done by a small task force. Various ways of organizing the emerging items of purpose and content were suggested. These included a division of primary, secondary and "tertiary" (services) production and a circular diagram with people (pupils) at the centre, followed by technology, the disciplines, etc...

The question of what distinguished technolgy from science was posed. One answer was that it focused on problem solving and had an intrinsic social dimension. The socio-economic dimension was seen as essential, and a study of Russian technological education as a source of data and ideas was suggested.

Technology Education for Careers.

1. The impact of information technology on science and technology education.
   (Bryan R. CHAPMAN)

Technology education should be able to anticipate the nature of employment in the future. The impact of new technologies on the level of employment will be highest in the high technologies. When the consequent cost of high technology is lower than that of labour, where will the 500 million new jobs in the Third World come from? On the other hand, services, health, education and leisure could provide most of these jobs but they will use the technologies rather that the processes of technology. In other words, it is important that education should embrace the tools of technology and not expect everybody to be prepared for using the task processes of technology.

In discussion, other points of view were put. The problem solving nature of the technological process could not be dismissed. Every career involved the solving of problems.

What was needed was clarity of thought about the nature of the problems and of the contexts in which they needed to be solved.

2. Post-secondary technical school teachers' perceptions of the impact of technological change on their professional activities.

   (David F. TREAGUST)

The role and policies of T.A.F.E. (Technical and Further Education) in Australia were examined together with the effect of Technology on T.A.F.E. progress. While T.A.F.E. provided a positive reaction there was a difficulty of keeping up-to-date, there was a need for a higher level of responsiveness to technological change. The need was for technological resources, staff development, more streamlined curriculum development, encouragement of staff to accept responsibilities and access to improved relations with industry.

3. Technology Education in the United States: A case study of a state in transition.

   (Ronald D. TODD)

Technology was being introduced to balance the Humanities, Sciences and Arts structure of secondary education. Technology is seen as a means of integrating the many skills being developed in schools. The Framework of Technology comprised: Elements (Humans, information, process, materials, energy and tools, e.g. transferable concepts, etc.), Systems (e.g. constructing, transporting, producing, communicating), Growth, Control Systems, Impact, Decisions.

B: ISSUES AND RECOMMENDATIONS ARISING FROM THE EDUCATIONAL FRAMEWORK FOR TECHNOLOGY.

The Educational Framework for Technology

The Working Group took the principal feature of the educational framework proposed by Peter EDWARDS and extended it in order to accomodate the issues regarded as significant in the different countries represented.
The extend framework is outlined below in such a way that detailed issues discussed may be articulated with each other and related to the overall concept of technology education.

1. Technology
1.1 The Nature of Technology
1.1.1 The PURPOSES of Technology
 - choice, values, morals and ethics, etc.
1.1.2 The PROCESSES of Technology
 - design, problem solving, manufacture, testing,etc.
1.1.3 The RESOURCES of Technology
 - knowledge (of science etc.), skills (intellectual and physical), experience, etc. as well as the material.
1.2 Contexts of Technology
1.2.1 Scale: personal, local, national, world.
1.2.2 Economic growth: extractive and productive industry.
1.2.3 Services: health, communication , transport, education, etc.

2. Technology Education
2.1 Nature of Technology Education
2.1.1 Education about Technology (e.g. Awareness).
2.1.2 Education using Technology (e.g. Educational Technology).

2.1.3 Education for Technology (e.g. Technological
Capability, Vocational Preparation).

2.2 Purposes of Technology Education
(General Education, Vocational Training)

2.2.1 National, e.g. survival
(economic, agricultural, health, defence)

2.2.2 Personal
(achievement, fulfilment)

2.3 Aims of Technology Education

2.3.1 AWARENESS

To develop awareness of the nature, potential, implications and responsibilities of technology; positive attitudes towards technology.

2.3.2 CAPABILITY

To develop competence and capabilities to engage in technological tasks.

2.3.3 RESOURCES

To prepare for engagement in technological tasks by developing the necessary personal resources of knowledge (techniques, processes and concepts, etc.), of physical and intellectual skills, of personal qualities (of enterprise, resourcefulness, imagination and sense of purpose, etc.) and experience of successful engagement in technological tasks.

2.4 Relevance of Technology Education

2.4.1 Relevance to Everyday Life

2.4.2 Relevanve to Responsible Citizenship

2.4.3 Relevance to potential careers

3. Technology Education in the Curriculum

3.1 Curriculum Location of Technology Education

3.1.1 Specific subject for Technology
- scientific, technical

3.1.2 Technology across subjects
- integrated sciences, technical,
- co-ordinated arts, humanities.

3.2 A Pedagogy for Technology Education

3.2.1 Interaction of concepts and skills - Resources

3.2.2 Interaction of resources and tasks - Capability

3.2.3 Development from teacher-directed to pupil-initiated tasks

3.3 Progression - from primary to secondary to higher education

3.3.1 Development of skills in designing, problem solving, manufacture and testing.

3.3.2 Development of multiple concepts and skills from across the curriculum and

3.3.3 increasing experience of real world tasks.

3.4 Assessment - Criteria relating to aims - progression.

3.5 Content - knowledge, skills, personal qualities, experience.

3.5.1 Content of a Technology discipline.

3.5.2 Technological content within other disciplines.

4. Children

4.1 "Target" groups

4.1.1 Differential needs.
Schools appropriate to needs of pupils.

4.1.2 "Technology for all".

4.1.3 Gender balance.

4.1.4 Ability levels.

4.2 Children's attitudes to Technology

4.2.1 Concepts of Technology.

4.2.2 Relevance - to careers, survival, personal development

5. Teachers

5.1 Teachers' attitudes to Technology
- Subject base
- Responsibility

5.2 Teachers' competence to teach Technology
  - Subject base
  - Staff development

6. Management of Technology Education

6.1 Lessons from history
  - for the present
  - for the future

6.2 Need for overall school management of Technology.

6.3 Need for government and political support.

Issues in Technology Education

In developing the Framework, many of the issues in Technology Eduction become apparent and are implicit in the preceding section. Particular issues were explored:

1. Value issues

1.1 The meaning of "quality of life" is ambiguous. Decisions to improve the quality of one person's life may significantly reduce somebody else's. Technology education should aim to develop quality of life on a worldwide basis, to the disadvantage of no one.

1.2 There may be a dilemma, in deciding on Technology Education, between national and personal interests. This may include deciding on priorities in content and approach between emphases on knowing about Technology, familiarity with the use of Technology, and capability to engage in the problem solving processes of Technology. It may include balancing "Western" Technology against indigenous Technology.

Pressures of vested interest groups, such as multinational companies, may obscure fundamental values and distort technology education.

Such issues about the nature of Technology Education can only be decided by the individual country concerned but there is a need to develop a fundamental ethical framework for Technology acceptable to all countries.

2. National Relevance

2.1 There is a need for a systematic transfer of Technology from the national environment into the schools.

2.2 There is a need for continuing education after school, to help the adult population accept and take advantage of technology.

2.3 There is a need for national realism on technological priorities, e.g. for the "post-industrial" society with its cheap, multi-national, availability of high technology; and a flexible attitude to changing needs.

3. Pupil Relevance

3.1 Different attitudes towards, and expectations of, Technology Education indicate a need for school curricula to match the diversity of individual pupils.

3.2 The development of technological capability, itself,falls for individuality of performance. It cannot be prescribed so that everybody knows and does the same thing.

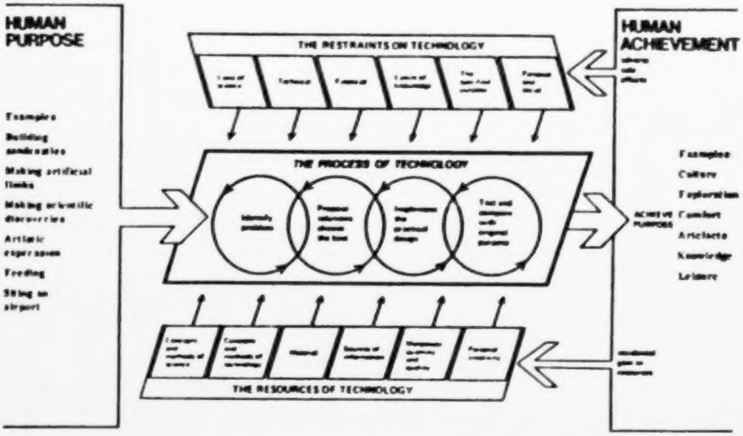
3.3 Technological education should, therefore, be provided with as much diversity of choice of content and learning styles as possible.

4. Curriculum Content of Technology

4.1 Once the value fields have been determined and the outline of relevant curricula can be determined, it is essential that a clear framework for learning about Technology should be made available.

4.2 This framework should be based on the model for

Technology used in each of the preceding International Symposia, namely


HUMAN PURPOSE
Examples
Building sandcastles
Making artificial limbs
Making scientific discoveries
Artistic expression
Feeding
Siting an airport
THE RESTRAINTS ON TECHNOLOGY
THE PROCESS OF TECHNOLOGY
THE RESOURCES OF TECHNOLOGY
HUMAN ACHIEVEMENT
ACHIEVE PURPOSE
Examples
Culture
Exploration
Comfort
Artefacts
Knowledge
Leisure

4.3 On this model should be structured:

4.3.1 a framework for resources of concepts and skills,

4.3.2 a framework for considering purpose, values, effects and spin-offs,

4.3.3 a pedagogy for learning to relate knowledge to the process skills of using it in the technological tasks of the real world,

4.3.4 a pattern for international research programmes to develop such frameworks and pedagogy.

5. Teacher supply and training

Technology does not fit readily into the conventional repertoire of many teachers currently in schools. A move towards technology will require massive retraining of teachers on programmes matched to their existing expertise.

5 GROUP REPORTS

5.3 Glen Aikenhead:
Main working group: Science-Technology-Society (STS)

Introduction

The STS Working Group's penetrating deliberations uncovered a rich array of issues. The quality of the papers, the presentors' self-discipline in speaking for a short time, and the preparedness of the participants in the audience, all contributed to the transcendental liveliness of our discussions.

This synopsis conveys the essential issues and key points in our discussions. Missing, because of the natural limitation of space, are the key points brought out in the papers presented at the Symposium. These, however, may be found in Volume II of Science and Technology Education and the Quality of Life (K. RIQUARTS, ed.).

The synopsis has been composed, in large measure, by the Working Group itself. Thus, it represents the views of those who thoughtfully engaged in the deliberations throughout the Symposium. Some of the participants had exchanged ideas and papers before the Symposium. This came about because of their membership in a STS Research Network, a special interest group within IOSTE which was established at the 2nd and 3rd Symposia at Nottingham and Brisbane.

General Points

What is STS? As indicated in Figure 1 (solid arrows), students integrate their personal understanding of the natural world with both the man-made world and social world of day to day experience. The study of the natural world is science. The study of the man-made world is technology. And society is the social milieu. Science-technology-society science instruction refers, therefore, to teaching about natural phenomena in a manner that connects science with the technological and social worlds of the student (the broken arrows in Figure 1).

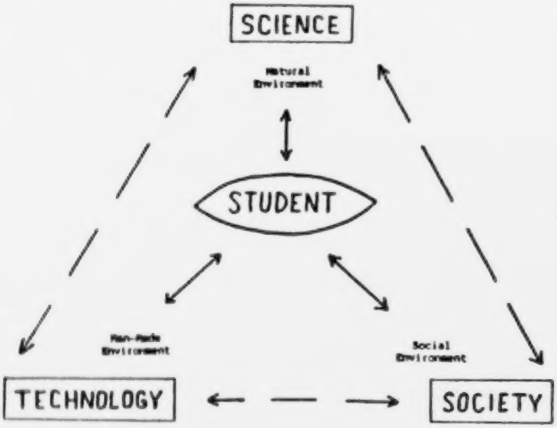

SCIENCE
Natural Environment
STUDENT
Man-Made Environment
Social Environment
TECHNOLOGY
SOCIETY

Figure 1

The Working Group believed that STS should be part of all science and technology courses. Indeed, this belief was underlined by the participants' interaction with the other two working groups throughout the Symposium. The inclusion of a STS approach in traditional courses, however, raises a host of interrelated complex challenges at all levels of education. Therefore, a holistic view, rather than a reductionist approach, is needed in implementing STS instruction. STS instruction and its implementation must necessarily be different in different countries and in different communities. The unique character of each situation can have a dramatic effect on the development and implementation of a STS approach. In other words, STS instruction is more context specific - more relevant to students - than the instruction of pure science content.

The Working Group discovered that in spite of spending between 60 and 90 minutes of discussion at each session, there was insufficient time to explore systematically the full range of STS issues that we and our colleagues face. Consequently, this synopsis is not a systematic treatment of all relevant STS issues. Rather, it is a record of the participants' comments on what they felt were the essential issues. The group recommended that within the 5th IOSTE Symposium, specific issues in STS instruction be addressed. Such an arrangement could focus attention on a systematic treatment of selected issues.

Specific Points

Our discussions tended to revolve around six topics:

1. Policy - what should be done in science and technology classrooms to benefit students and society?
2. Materials - the development of all media for student use.
3. Teachers - teacher background; e.g. preservice experiences, personal goals.
4. Instruction - the repertoire of teaching strategies effective for STS instruction.

5. School Setting - the influences and consideration of students, other teachers, administrators, the community, ministries of education, the universities, etc.

6. Evaluation - the assessment of student progress (formative and summative) by the teacher and also by the authorities, the assessment of the course by the teacher or authorities, and the assessment of the science and technology programme by the authorities.

Because the 1984 Brisbane Symposium was dedicated to the issue of policy, the Working Group decided not to give it prominence here.

Materials

1. Separate STS courses versus infusion (integrated or "piggy-backed") of STS into existing courses: While separate STS courses offer systematic STS instruction balancing basic science content with its technological and social milieu, in most school systems the number of academically oriented students enrolling in STS courses is limited, and thus nonacademic students are often designated for such courses. On the other hand, integration of STS into existing courses (e.g. physics in society) will reach a wider group of students and will not explicitly compete with the status quo; however, implicitly, the STS content will compete with other day to day demands and routines of teaching, and consequently the STS aspects will tend to be shelved easily, due to their infusion status. The Working Group suggested that the infusion or integration of STS into existing course material will likely be the preferred way to proceed. Research on both approaches is needed to illuminate the strengths and weaknesses of each type of material. Another recommendation calls for clarifying these different types of materials by constructing a framework that would allow

one to identify different approaches. An inventory or annotated bibliography was also recommended.

2. Different STS materials emphasize different aspects of STS science content: (a) the nature of science - the epistemology and sociology of science and technology; (b) social issues; e.g. pollution, nuclear war; (c) content of the discipline - where aspects a. and b. arise within the discipline content. Over an entire curriculum there should be a balance. Studies need to investigate the successes at achieving STS goals for various emphases and for different time allocations given to aspects a. and b.

3. What topics or issues convey most powerfully STS understandings and skills? This question could be resolved through opinion research (e.g. Delphi studies), through analysis of mass media and policy documents, and through analysis of traditionally taught science content to identify related technological and social issues.

4. What methodologies should be structured into the materials? Decision making appears to be a consistently emphisized skill for all STS materials. There is a great need to investigate the effects of STS instruction on students decisions, on the way in which students arrive at their decisions, and on the quality of their arguments.

Teachers

1. Undergraduate science programmes: The research shows that few students graduate from conventional science degree courses with a significant STS perspective. Thus, IOSTE, needs to work to influence those who teach undergraduate science courses to incorporate at least one significant STS unit in each course for all students. (This task may be as difficult as relocating a cemetery).

2. Practice what you preach: Teacher educators themselves must demonstrate by their own teaching of trainee teachers the diversity of instruction techniques essential for STS; for instance, teacher-student collaboration, plus flexibility, for incorporating topical events and local examples into science lessons. By their example, teacher educators need to show the limits of their own knowledge and to show their students how to (a) learn from colleagues, and (b) learn from their students by joint preparation of some STS materials. Preservice education courses can only orientate students towards STS teaching and towards the necessary skills. More coordination is needed among preservice courses, induction into the classroom, and inservice education.

3. Research: What personal qualities or experiences are important for successful STS instruction? Longitudinal studies should identify the factors that sustain and encourage students/teachers to persist in their STS learning/teaching. What factors and conditions encourage and discourage the interdisciplinary teaching team which is potentially valuable for STS instruction? What causes certain teachers to declare their resistance to specific STS topics?

4. The Working Group recommended that within IOSTE, teacher educators share materials and ideas for preparing trainees for STS instruction; and then identify and develop needed materials.

Instruction

1. Richer goals: STS instruction provides special opportunities to develop intellectual, social and personal goals for students; goals that are not usually available in conventional science courses. These goals include: self-esteem, written and oral communication skills,

logical thinking and reasoning skills for problem solving, decision making, collaborative/cooperative learning, social responsibility, active citizenship, cognitive flexibility, and an active interest in social issues.

2. Diversity of strategies: Strategies for STS science are many and varied. In addition to lectures, demonstrations, questioning sessions, word problem solving practice, and labs; STS instruction includes: simulations, games, role play, forums and debates, individual and group projects, letter writing to authorities, active research, field work, guest speakers, and community action. These teaching strategies are complex and demanding of the teacher. Working collaboratively with others, including the students, shifts the teachers's role to a classroom manager (managing time, people, resources and the emotional climate of the classroom), away from the role of classroom performer. This shift in one's teaching role may not complement a teachers's personal traits, and thus resistance should be expected.

School Setting

1. Student learning: STS instruction addresses the need for helping students build "bridges in the mind" between expert knowledge on the one hand, and lay or common sense knowledge constructed from everyday experiences, on the other. In other words, STS teaching introduces students to "curriculum knowledge" and guides them as they make their own meaning out of it in terms of their "personal knowledge". Research is needed on appropriate and effective instructional strategies or interventions.

2. Student reasoning: Are the reasoning abilities of students sufficient enough to engage in STS content (e.g. probabilistic reasonirg, or recognizing logical fallacies)? Can we teach students to transfer their

reasoning skills taught in one context (the classroom exercises) to other contexts (the everyday world)?

3. Students needs: The needs and values of students vary according to the interests, abilities, age level, and social setting of the student. How do these factors affect what students learn from STS instruction? How do student values interact with the values/ideology of science and technology?

4. Perceived status of STS courses: Teachers have practical concerns over maintaining status, resources and territory in relation to other teachers, administrators, the community, and university science professors. We need research to document experiences of a wide variety of teachers and curriculum developers in order to clarify the politics of policy making in STS education, and the politics of implementing STS instruction.

5. Academic rigor: STS instruction must be rigorous and it must NOT be just for nonacademic students.

6. Special interest groups: A great deal of time was taken in discussing those groups which have a powerful influence on curriculum and instruction; e.g. universities, examining boards, parents and textbook publishers. There is a great need to build collaborative networks between STS educators and groups which can provide political leverage to support STS instruction. Support from powerful agencies, such as The Royal Society, and from key individuals within agencies, such as a progressive science professor, must be built in order to create a favourable climate to encourage and sustain the STS approach to teaching. Lobbying is part of a STS educators' role.

Evaluation

1. Difficulty of evaluation: The paucity of research and development for STS curricula was noted. This state of affairs suggests that STS content is more difficult to assess than the memory work of traditional science classes. By insisting that the evaluation of students be concurrent with STS goals, STS educators have set high standards for the assessment of students' personal knowledge. Evaluation of students in conventional science courses rarely attempts such high standards.

2. Development of techniques: STS teachers need help in developing and using various strategies that assess student achievement of STS goals. STS programme and curriculum developers need help in putting together research and evaluation studies. The merits of theoretically constructed multiple-choice items and empirically developed multiple-choice items were debated. Direct comparisons between the two types of items were called for. Many more techniques must be developed and documented, however.

3. The future: Given the fact that educators seem least secure in the area of evaluation and that there appears to be a paucity of help for STS educators, the issue of evaluation should be a specific concern for future STS conferences.

Conclusion

This synopsis has described the ground we walked during the 11 STS Working Group sessions, plus the reflections we had on what our next steps should be. We have given ourselves specific goals for the 5th IOSTE Symposium. At the same time, we have strengthened the support network among STS researchers and developers.

6 SUMMING-UP

6.1 William Hall:
Vision and prospect: A generalistic view on the symposium

Introduction

The theme of the symposium was "Science and technology education and the quality of life". There were three sub-themes:

- the impact of science and technology education on everyday life
- decisions which a responsible citizen has to make
- future careers, with special regard to the products of scientific and technological research.

The big question which arose in my mind during the symposium was: what has science and technology education got to offer our lives as citizens, our lives as employees, and our lives as employers, given the present rate of change? This question has a direct bearing on the theme and sub-themes.

Imagine that all of the symposium proceedings were placed into a distillation flask. What are the main products of the distillation to emerge? For me, there were four:

- rate of change
- quality of life
- employment
- education.

Not surprisingly, these four products of the "distillation" are components of the big question which I have already raised. Therefore my comments on the symposium will be under these four headings; and my comments will help to determine my answer to the question.

Rate of Change

In the history of mankind there have been six technological revolutions. These are shown in figure 1.

The period of time between revolutions has shortened from millions of years to less than one hundred years. Most of us can confidently expect to live through at least one more revolution, perhaps two. Are we exited about this? Or does the thought depress us? How should we prepare our students for such a rate of change? And how soon should we introduce new techniques and new technologies into syllabuses? The importance of the cycle shown in figure 2 has some bearing on these issues.

In the symposium I found little which tried to conceptualize technological change, and the STS movement has been especially remiss in that regard. Mr. CHAPMAN expressed one product of change: information technology; and his conclusions have important consequences.

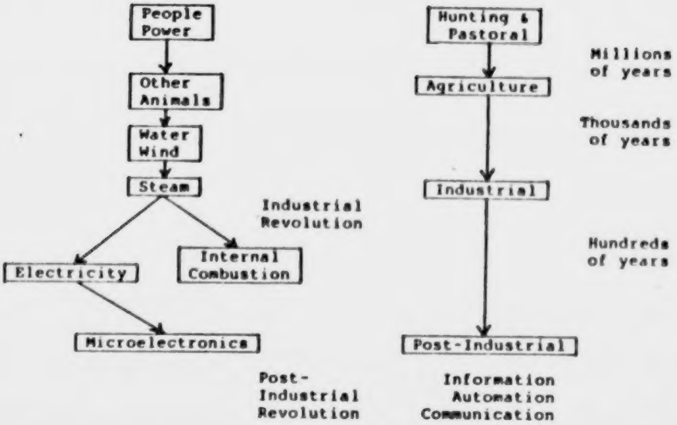

People Power
Other Animals
Water Wind
Steam
Industrial Revolution
Electricity
Internal Combustion
Microelectronics
Post-Industrial Revolution
Hunting & Pastoral
Millions of years
Agriculture
Thousands of years
Industrial
Hundreds of years
Post-Industrial
Information
Automation
Communication

Figure 1: The six technological revolutions

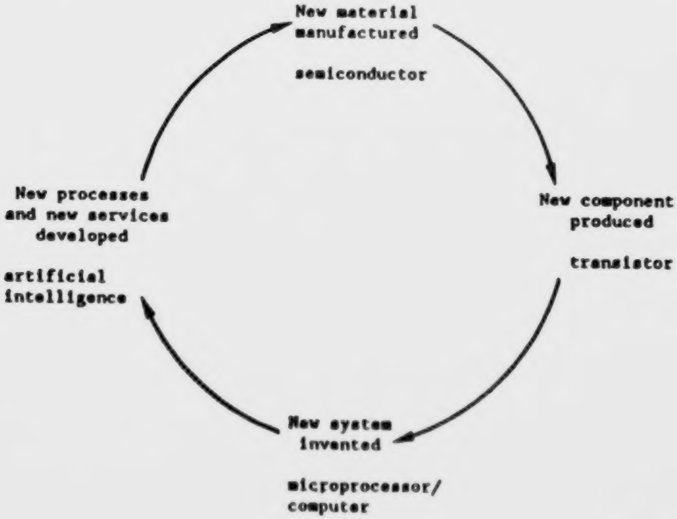

New material manufactured
semiconductor
New component produced
transistor
New system invented
microprocessor/ computer
New processes and new services developed
artificial intelligence

Figure 2: The new technologies cycle

Change is a major scientific and technological concept; and it is increasingly becoming more important as an everyday concept. Some of the developing countries in their papers showed that they had a good understanding of the concept's importance and Dr. NACHTIGALL in his plenary address "New priorities in science and technology education" talked about the concept's importance; but these speakers were exceptions, because most workshop presentations did not consider the concept.

Quality of Life

There are five important generalizations which arose in the symposium regarding "quality of life". These are:

- quality of life has different meanings for different people;
- science and technology are not the sole (or even the main?) contributors to "quality". Nevertheless, they do have important contributions to make;
- scientists and technologists are people. What they handle may be amoral, but they cannot be neutral;
- the scientific way of thinking is often quite inappropriate to many of the "quality" issues;
- an improvement of "quality" in one part of the world could lead to a worse standard of living in a different part of the world.

The (so called) developing countries have much to teach the (so called) developed countries about "quality". Science education is being put to very practical purposes by many developing countries, including

- health education for children (Brazil)
- home based science (Nigeria)
- rural development (India).

There are examples from some developed countries including energy education in the USA. It would be interesting to evaluate the effectiveness of these programmes and to report back to the fifth symposium.

For too long pure science has taught the spurious picture shown in figure 3. Instead, the second law of thermodynamics needs to be remenbered, as in figure 4. This (more scientific) model has profound implications for quality of life issues.

In considering quality of life issues, we do well to remember the definition of technology. Trent Polytechnic has done much to develop a practical, understandable, model based on their definition (figure 5).

Perhaps we should remind ourselves of the UNESCO definition:

> "Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems, to enhance controls over the natural and man-made environment in an endeavour to improve the human condition".

The technology working party at the symposium devoted much time to definitions and models and this theoretical underpinning is reflected in their report. Such theoretical underpinning was absent from the STS discussions and it is my view that the movement will progress little until it has such a theoretical framework. Theoretical structure is important so that the breadth of coverage is known (limits are imposed), so that what is taught and how it is taught can be influenced.

Employment

Frequently, we forget that most of our students are studying in order to obtain qualifications so that they can get a job.

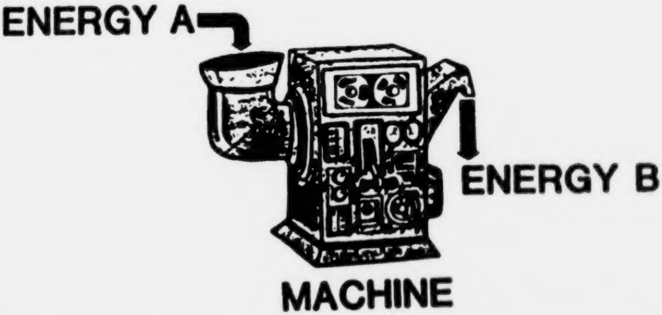

ENERGY A
ENERGY B
MACHINE

Figure 3: The scientific (perfect) machine

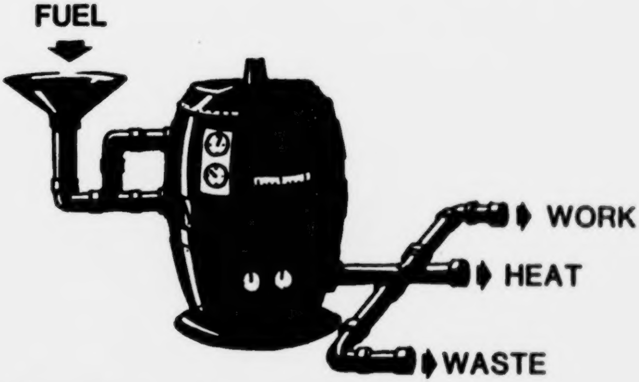

FUEL
WORK
HEAT
WASTE

Figure 4: A machine

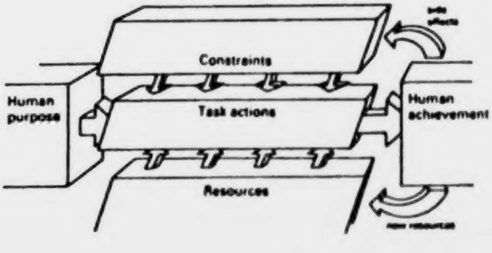

side effects
Constraints
Human purpose
Task actions
Human achievement
Resources
new resources

Figure 5: The Trent Polytechnic technology model

This applies to arts as well as to science and technology students. Employment is changing (that word again!) dramatically both in terms of the effecting of technological change and in terms of areas of growth and areas of decline.

The UK's Manpower Service's funded "Technology Monitor" has followed new technology trends in that country and a list of the more important recent findings follows:

- numerical controlled tools
- robotics
- CAD/CAM
- flexible manufacturing and process control systems
- process sensors
- telecommunications
- reprographics
- data processing equipment
- laser and optical devices
- transport systems
- new materials
- biotechnology.

Just consider one of these: new materials manufacture and use. The literature suggests that there are likely to be nine important developments:

- high performance ceramics (as substitutes for metals)
- syntheric membranes (for new separation technology)
- strong engineering plastics
- polymeric materials with high electrical conductivity
- advanced alloys
- composite materials
- adhesives
- coating processes
- macro-defect-free (mdf) cement.

How is the content (dirty word!) of our courses going to be affected by such changes? A number of speakers referred to technological change, including the teaching of biotechnology at school, but most have ignored curriculum content issues.

In Australia a Federal member of parliament, Barry JONES, has predicted that we are now moving to a post-service economy, as shown in figure 6.

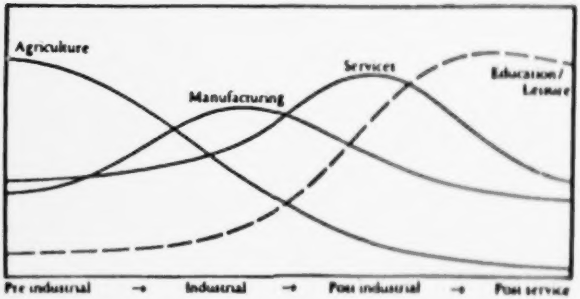


Figure 6: Towards a post-service economy (according to B. JONES: Sleepers, wake! In: I. LOWE (ed.): Teaching the interactions of science, technology and society. Melbourne, Longman 1987).

How will science and technology education respond to such changes?

Education

As one workshop speaker said, we have spent far too long approaching education as something that people should learn; we need to change what people need to learn. The "should learn" approach has dominated Western industrialized countries, producing narrow specialists with little empathy for (for example) STS teaching. Although there are encouraging signs in some countries, STS in other contries is under attack. One solution suggested at a workshop proposed an approach through vocational education, using the model shown in figure 7.

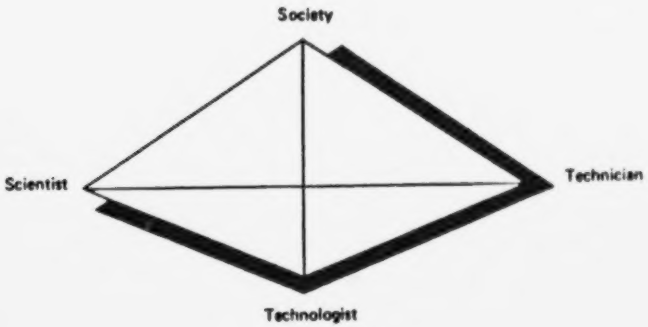


Figure 7: The STST model

Various attempts are being made around the world to provide courses on what pupils need to learn, including:

- integrated science (Netherlands, India)

- non-formal approaches, such as the community learning exchange (USA); invention fair (USA); and out-of school activities (China).

- technology education is a formal, important (and compulsory) part of the school curriculum (UK, Nigeria).

I must say, I liked the slogan "technology for all, science for some". However, of very great worry to me so far as some developments are concerned was:

- apparent lack of structure
- apparent lack of theoretical basis
- lack of curriculum model
- lack of progress in thinking over the past ten years.

Frequently, we just have scientific stamp collecting. Bits and pieces of content with no particular shape or overall intention in mind.

In all countries, the problem of scientific illiteracy remains. An amusing piece of writing (from PUNCH, 10/7/69) illustrates this.

> "I have picked up a pretty sound working knowledge of electrical matters. It is not comprehensive, - I still can't fully understand why you can't boil an egg on an electric guitar - but when I jot down a summary of what I have learned, I marvel that I have never been asked to write for the Electrical Journal:
>
> 1. Most electricity is manufactured in power stations where it is fed into wires which are then wound around large drums.
>
> 2. Some electricity, however, does not need to go along wires. That used in portable radios, for example, and that used in lightning. This kind of electricity is not generated but is just lying about in the air, loose.
>
> 3. Electricity becomes intensified when wet. Electric kettles are immune to this.

4. Electricity has to be earthed. That is to say, it has to be connected with the ground before it can function, except in the case of aeroplanes, which have separate arrangements.

5. Electricity makes a low humming noise. This noise may so pitched at different levels for use in doorbells, telephones, electric organs, etc.

6. Although electricity does not leak out of an empty light socket, that light socket is nevertheless live if you happen to shove your finger in it when the switch is at the "on" position. So if it is not leaking, what else is it doing?

7. Electricity is made up of two ingredients, negative and positive. One ingredient travels along a wire covered with red plastic, and the other along a wire covered with black plastic. When these two wires meet together in what we call a plug, the different ingredients are mixed together to form electricity. Washing machines need strong electricity, and for this a booster ingredient is required. This travels along a wire covered with green plastic.

8. Stronger electricity cannot be used for electric razors. Electric razors make a fizzing sound when attached to a power plug.

9. Electricity may be stored in batteries. Big batteries do not necessarily hold more electricity than small batteries. In big batteries the electricity is just shovelled in, while in small batteries (transistors) it is packed flat.

10. Electricity is composed of small particles called electrons, an electron weighing 1/1.837 as much as an atom of the lightest chemical element, hydrogen, unless the Encyclopedia Britannica is a liar."

One encouraging sign in this symposium has been the recognition that as science technology educators we are involved in an intensely political activity. For too long educators have been isolated from political reality, but all of that is now changing, and changing rapidly. Professor NACHTIGALL raised important issues in his lecture, including

"What will be the outcome of my doing?
"What would happen if everyone did that?"

Political pressure was recognized by Dr. KAHN from the University of Botswana in his paper "Attitudes of policy awareness towards science and society issues in a developing country". The fact is, education is very much a part of the political network with all of its pressure, as Robert COPE of the University of Washington has shown.

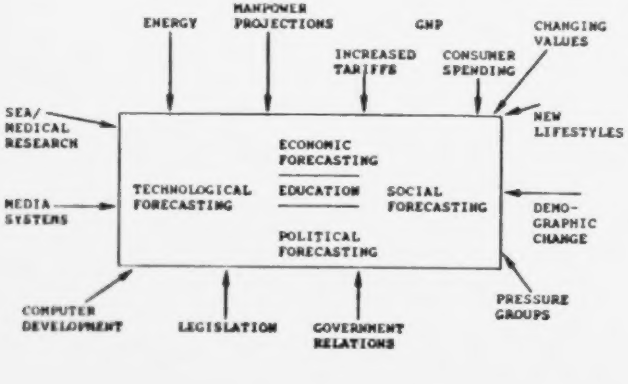

ENERGY
MANPOWER PROJECTIONS
GNP
CHANGING VALUES
INCREASED TARIFFS
CONSUMER SPENDING
SEA/ MEDICAL RESEARCH
NEW LIFESTYLES
ECONOMIC FORECASTING
TECHNOLOGICAL FORECASTING
EDUCATION
SOCIAL FORECASTING
MEDIA SYSTEMS
DEMO-GRAPHIC CHANGE
POLITICAL FORECASTING
PRESSURE GROUPS
COMPUTER DEVELOPMENT
LEGISLATION
GOVERNMENT RELATIONS

Figure 8: Strategic planning pressure (by COPE).

Summary

Futurologists have predicted that we shall face four major challenges over the next decade:

INFORMATION EXPLOSION

INCREASE PACE OF CHANGE

SOCIAL PROBLEMS

IMPORTANCE OF PERSONAL FULFILLMENT

As educators we are in good positions to prepare society for those challenges. We can do something. What shall we do? As the Bible tells us: where there is no vision, the people perish. What is our vision?

Well, then, has the important question which I raised at the beginning been answered by the symposium? My response must be: only in part. The positive outcomes have included developments in school technology, in appropriate technology and in the changes to science syllabuses in some countries.

On the negative side, we seem to have avoided some of the really big issues, and many of the papers could have been prepared 10-15 years ago, which is not good enough for a symposium with the world trends label attached to it.

What is your vision?

6 SUMMING-UP

6.2. Peter Häussler, Jack Holbrook: Summing-up the Symposium and Final Recommendations

As the symposium was divided into three main parallel programmes, the following summaries, comments and recommendations appropriate for the next symposium are subdivided in the same way. They are partly based on the reports of the three groups (cf. chapter 5), partly on the final plenary discussion on the last day of the symposium.

From the Working Group on Science Education

More than 50 papers were presented showing diversity and richness of developments in science education from all over the world and covering education from early childhood to adulthood, from single classroom events to educational policy decisions for a whole country. Four trends clearly emerged which turned out to support each other in a promising concept that was felt to be worth promoting in a joint effort.

1. Science for All

Today science education all over the world is directed at all students. It is concerned with enhancing their understanding of natural and technical processes and developing their creative and productive potentials. These are considered indispensible prerequisites for upgrading the quality of life. To support the intention of improvement in joint efforts common core curriculum for all is envisioned.

2. Science Education in the Community

The proof that science and technology can be productive and promising for cultural development will have to be given in the places where culture unfolds - the communities.

As a result of some promising evidence that the transformation of general science knowledge and technological know-how to the community level is possible it is proposed to implement the science curriculum in consideration of the needs existing in the different communities.

3. Science Education for Women

A Science Education for All will have to be conceptualized as science education for girls and women. Empirical research and various development programmes give clear evidence favouring this approach. It appears that the community orientation for science education is a valuable contribution to this end and vice versa.

4. In-School and Out-of-School Learning

The above approaches for improving science education can be supported and extended by a complementary system of in- and out-of-school learning chances. Obviously, a programme of science education for all cannot confine its activities to the public school system because in many countries formal education does not reach all children.

The cultural diversity does not allow precise proposals for out-of-school science education. If the core curriculum is institutionalized through the formal school system, a non-formal system should guarantee its extension to those not reached by formal schooling.
Public media like radio, television, newspapers or periodicals would be part of this joint effort.

It was agreed upon that improving the quality of life by science education will mean different things in different societies. However, beyond these differences the working group's discussions revealed a common intention of improvement to be
(1) democratic
(2) non-destructive
(3) compensatory
(4) need-oriented
(5) convivial, i.e. favouring common use and availability for all
(6) ecological
(7) moral.

The expected improvements are tightly connected with existing and anticipated teacher qualification. Without upgrading the teaching profession improvements are highly improbable. Besides raising the teachers' social status and offering incentives for extra efforts, the following is required:

- institutionalization of pre- and in-service training,
- improvement of material conditions for teaching and learning,
- organizational support systems for and between schools,
- research capacities for development in science education.

From the Working Group on Technology Education

It was advocated by the group to accept a definition of technology education and to give attention to the means by which this can be incorporated in the classroom. In this attention needs to be given to

(a) the content of such courses and the methodology appropriate for presenting such technology,

(b) the teacher preparation and teacher support necessary for such content to be implemented.

It was suggested that such an appropriate definition of technology education be that as presented by UNESCO:

> "Technology is the know-how and creative process that may utilize tools, resources and systems to solve problems, to enhance control over the natural and man-made environment in an endeavour to improve the human condition".

It was advocated to re-affirm the integrity of the model for technology which has been used in all IOSTE Symposia. It was recommended that IOSTE take every opportunity to support this model.

Further, it was recommended that IOSTE regard technology as not deriving only from science. They have developed together, have interacted and provide mutual support. They are dependent on each other. The product of science is knowledge of a particular aspect of the universe. On the other hand, there is technology of pottery, beef production and many human activities. Technology is "intuitive" and "artistic" as well as "scientific".

Technology Education is an essential part of General Education. It has Technology, as its focus, which is seen as a major activity of human beings as they seek to develop, control and improve their world. The advancement of Technology challenges mankind to reconsider the meaning of being human.

In the fullest interpretation of Technology Education there will be pressure first for technological awareness, then for technological understanding and, most deeply, for technological capability.

The Group recommends IOSTE to press for this full interpretation of Technology and of Technology Education, to all children in schools.

The statement that technology exists to meet human needs conceals the fact that meeting the needs of one set of humans is often in conflict with those of another. Some of these issues will, undoubtedly, be politically sensitive and government and teachers engaging in Technology Education should be aware of this. An example of this is the creation of employment in one area of the world at the expense of employment in another.

The educational aspirations of an individual student may conflict with national needs.

In advanced societies where automation and robotics are increasingly reducing the need for (traditional) skills Technology Education may need increasingly to become a vehicle for personal education of the kind which will provide a basis for adult life in an information technology society. Unless it is clear to students that Technology Education is just as important and prestigious as other curriculum subjects there is a danger that it will not get the allegiance of able students.

A pupil's concept of technology will be shaped by the technological education he receives. It is therefore important that those engaged in teaching technology should strive to put this education in an economic, political and social context and not just be concerned with the technical aspects of problem solving.

The aims and objectives of Technology Education are well understood to include the consideration of the aesthetic, economic, political and social dimensions of technological problem solving. The Group believes it important to re-emphasize these aspects to technological education. In some circumstances these may be more important than the problem solving itself.

Educating pupils in technology is a way of educating young people from the primary school upwards. We would expect all groups of pupils to participate fully in this, although it would be unrealistic to expect all societies not to have different requirements of different sections of the population at a later stage. It is important, therefore, to recognize that a diversity of activities are embraced by the technology concept.

Key restraints on any developments in Technology Education are

(a) a lack of source of new teachers,

(b) a lack of background to the broad dimesions of technology concepts amongst the existing teaching force.

Any nation taking up technology education has to consider how it can solve the problems associated with these restraints.

Schema of technological education are now well understood in some countries but it is necessary for nations adopting them to exemplify them in ways appropriate to the particular adult world their students are entering. At primary level this may not matter and existing problem solving materials provide much of value here. For older pupils there is a need to widen horizons towards the outside world partly through resources, partly through contacts with the outside world (industrial links).

Technology Education must strive towards a situation in which people are in control of technological developments rather than controlled by them.

In many nations there may, at this stage of their development, be close links between vocational and technological education (solving immediate urgent quality-of-life problems of water supply, health, food production, rural industries, etc.). As countries become more developed this vocational element becomes increasingly the task of post-school education and school technology education becomes more concerned with giving awareness, through direct experience, of technological processes.

Technology Education may well have a curriculum slot in order to provide focus and direction but it should not be confined to a curriculum slot labelled technology. Unless it is also present in all other subjects, then students will leave school with an inadequate appreciation of how technology has, since the beginning of time, been a central feature of mankind's development. Geography, History, Literature, Social Studies, Biology, Chemistry, Physics, Mathematics even Religious Education, should pay some attention to the influence technology has had in the area of study with which they are concerned. To take up the theme of the keynote address, a technological perspective in all these subject areas could provide the 'glue' that gives 'wholeness' to a fragmented curriculum.

From the Working Group on STS

During the eleven STS working group sessions the following specific issues in STS instruction were addressed:

1. Status and content of STS courses

The working group suggested that the infusion or integration of STS into existing course material will likely be the preferred way to proceed, instead of having separate STS courses.

Research on both approaches is needed to illuminate the strengths and weaknesses of each type of material.

The questions of what topics or issues conveys most powerfully STS understandings and skills could be resolved through opinion research (e.g. Delphi studies), through analysis of mass media and policy documents, and through analysis of traditionally taught science content to identify related technological and social issues.

2. Teacher training

Few students graduate from conventional science degree courses with a significant STS perspective. Thus, IOSTE needs to work to influence those who teach undergraduate science courses to incorporate at least one significant STS unit in each course for all students.

Teacher educators themselves must demonstrate by their own teaching of trainee teachers the diversity of instruction techniques essential for STS. Longitudinal studies should identify the factors that sustain and encourage students/teachers to persist in their STS learning/teaching and the reasons why certain teachers declare their resistance to specific STS topics.

The Working Group recommended that within IOSTE, teacher educators share materials and ideas for preparing trainees for STS instruction; and then identify and develop needed materials.

3. Instruction

STS instruction provides special opportunities to develop goals that are not usually available in conventional science courses.

These goals include:
- self-esteem,
- written and oral communication skills,
- decision making,
- collaborative/cooperative learning,
- social responsibility,
- cognitive flexibility,
- an active interest in social issues.

STS instruction includes: simulations, games, role play, forums and debates, individual and group projects, letter writing to authorities, active research, field work, guest speakers, and community action.

4. School setting

STS instruction must have academic rigor and it must not be just for nonacademic students.

There is a great need to build collaborative networks between STS educators and groups which can provide political leverage to support STS instruction. Support from powerful agencies and from key individuals within these agencies, such as a progressive science professor, is necessary in order to create a favourable climate to encourage and sustain the STS approach to teaching.

5. Evaluation

STS content is more difficult to assess than the memory work of traditional science classes.

Therefore, STS teachers need help in developing and using various strategies that assess student achievement of STS goals. STS programmes and curriculum developers need help in putting together research and evaluation studies.

Given the fact that educators seem least secure in the area of evaluation, the issue of evaluation should be a specific concern for future STS conferences.

Comments and Recommendations on the Structure of the Symposium

(a) The decision to restrict the number of plenary sessions, thereby allowing more time for detailed discussion of the contributions in the pre-symposium publications - following the pre-arranged structure - was greeted with approval.

(b) It would be more effective and add further to the flavour of the symposium if exhibitions could not only be encouraged but displayed throughout the symposium rather than during one short session.

(c) A suggestion for the organizers of the next symposium would be to increase the time available for workshops - particularly during the afternoon sessions.

(d) Even more attention should be paid to identifying "good" projects, support materials, etc. that are presented at the symposium: It may be appropriate for IOSTE to recognize such efforts by the award of certificates or other means. (But: Who would make such judgements?)

Comments and Recommendations on Exchange of Information

It is important to build bridges to further enhance ideas and to exchange information in science and technology education/teacher education between the developed and developing countries and among the developing countries as well. This would be achieved

(a) by personal exchanges between institutions (e.g. through the UNESCO study visit program, organized by the "International Network on Information in Science and Technology Education" (INISTE) or other international and national organizations)

(b) by personal attendance at symposia whereby programmes, models or curricula could be experienced at first hand (e.g. participation in IOSTE- Symposia)

(c) by publications, e.g
- the IOSTE newsletter and its information service on the various interest groups within IOSTE

- the UNESCO newsletter of the 'International Network on Information in Science and Technology Education'
- the ICASE newsletter and those of its member associations.

Comments and Recommendations on Issues of Priority Need

Among others, the attention is drawn to the following issues, raised by the audience during the final plenary session:

(a) Out-of-school education

More attention should be paid to education outside the formal schooling as there is a need for STS education for the adult workforce, the educated elite and children drop outs or non-starters (D.C. GOSWAMI, India).

IOSTE should give consideration to the promotion of open learning institutions for the furthering of STS teaching (Ahmad OTHMAN, Jordan).

There is a need to give more emphasis to forming links between science education and the community (Roland LAUTERBACH, Federal Republic of Germany).

(b) Promotion of STS

It it important to address the issues from the perspective of those with frames of reference that may differ from the humanitarian view of educators. Policy makers e.g., politician and influential persons do not usually share the humanitarian frame of reference (Mark COSGROVE, New Zealand).

An attempt should be made to exchange ideas and experiences in teaching science and technology on a global and on a local scale (Henk SMIT, Netherlands).

More attention should be paid to involving the media. The media are an important factor that should not be overlooked especially if STS is to become a political force (Douglas CRAWFORD, Canada).

(c) Content areas of STS

Although we have given much attention to science and technology education, this is not among the key problems facing society. More important are peace and freedom espcially among the richer countries as well as justice, a concern for population growth and even survival in less rich countries and for the preservation of nature. There should be a greater effort made by STS to address such issues and to contribute to the solution of the fundamental problem: survival and development of mankind in dignity (Dieter NACHTIGALL, Federal Republic of Germany).

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IPN

The IPN (Institute for Science Education) is the research institute in science education with a national function in the Federal Republic of Germany. Through its research work it aims to further develop and promote science education. It is permanently financed by the Federal Government and the Land Schleswig-Holstein, together with the other Länder.

[illegible] 12 August 1987. [illegible] third volume contains the symposium proceedings.

A brief account of the symposium's design and structure is followed by
- a general introduction to the theme of the symposium
- an introduction to each of the three thematic areas of the symposium

[illegible]
- an evaluative summary of the symposium
- some final recommendations

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